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GENERAL HYGIENE

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THE

HEALTH EXHIBITION LITERATURE.

VOLUME X.

GENERAL HYGIENE.

HANDBOOKS.

ATHLETICS; OR, PHYSICAL EXERCISE AND RECREATION.
ATHLETICS. PART II.
DRESS, AND ITS RELATION TO HEALTH AND CLIMATE.
FERMENTATION.
PUBLIC HEALTH LABORATORY WORK.
LONDON WATER SUPPLY.

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HANDBOOKS.

PREFACE.

HYGIENE has been defined as the application of scientific principles to the varying conditions under which we live A perusal of the titles of the various Handbooks issued under the authority of the International Health Exhibition, affords some idea of the vast field of knowledge which must be traversed by the student of Hygiene; and this, the last volume of the series, which may be said to gather up what has escaped from previous volumes, may be well taken as an illustration.

A complete education in Hygiene embraces a knowledge not only of every function of life, but of the consequences which result from the performance of those functions.

The development of the various parts of the body cannot take place without use, and true physical education is the science which teaches the harmonious development of all parts of the human body, including the senses, such as touch, hearing, sight, and including the power of judging proportion. It is for this reason that those exercises should be sought which call the greatest number of muscles into play.

Games do not, as a rule, do more than exercise certain muscles, the bicycle is perhaps the form of gymnastic apparatus which trains the largest proportion of the muscles, but a rational system of free exercises, practised for a very short time daily, without gymnastic apparatus of any kind, is sufficient to secure the free use of the limbs, the development of the chest and of other organs, and generally militates against deformity.

But the unequal training of various parts of the body leads us to this further consideration: certain classes, accustomed to continual brain work, have an inherited capacity for it; and the standard of mental toil attainable by them cannot be compared with that attainable by generations of manual labourers. A true knowledge of the laws of Hygiene would teach us to apportion the teaching of those classes whose vocation is and has always been rather that of manual labour than brain work, more equally between brain work and the learning of handicrafts, or other physical training, than is now allowed in our Elementary Schools. And further, might not the hereditary tendency of the children of criminals to lapse into crime, be eradicated by directing into healthy channels the nerve and brain power which will otherwise act in criminal directions? The child of the forger might become an accomplished draughtsman, the child of the pickpocket might employ his delicate touch and deft fingers in watchmaking, or other similar trade, and so on. These are considerations which follow legitimately from the treatment of Athletics as a branch of Hygiene.

But when the Hygienist has rendered the human body perfect in shape by judicious exercise, his next object is to construct and decorate a covering for it which shall be healthy and beautiful. The very interesting Handbook by Mr. Godwin shows how the building of a dress or a costume demands just as much thought as the building a house, and that the subjects of heating and ventilation are as important to health in the case of the dress as of the house.

It is, however, a very remarkable fact that although the knowledge of the laws of Hygiene has been largely spread through the community in recent years, the dresses of the lady of the present day contain hygienic defects as glaring as many which prevailed in past centuries. Cannot beauty and health go together in dress as they do in the human body? Mr. Godwin tells us, that we take isolated views of Health and Beauty, and that the sanitarian has a smile akin to a sneer for the beautiful, whilst the person of taste

ignores every law, sanitary or otherwise, which interferes with his fancy. There is, perhaps, no subject on which so many minds are constantly employed, as that of dress; and we must hope that this International Health Exhibition will form an epoch in the history of dress, and that by degrees dressmakers will be induced to combine beauty with health.

In the course of his studies, the student of Hygiene passes from the body and its coverings to consider the continual changes which it undergoes. All organised matter is continually changing. It draws substances from the surrounding air and water, and converts those substances into other forms of matter, and throws them out in a form incapable of contributing to the nourishment of a new vegetable life. If it remained perpetually in this state, the atmosphere would be deprived of its elements of organism, water of its nutritive matter, and life would become impossible on the surface of the globe.

Of the Handbooks included in this volume, perhaps the most interesting, for the important bearing which the matter of which it treats has on the continuous circle in which life moves on the earth, is that on "Fermentation." We learn from it how vast a part in the living world is played by the action of minute organisms, such as yeast and other microbes, who are the agents of universal Hygiene.

Dr. Duclaux shows how they clear away more quickly than the dogs of Constantinople, or the wilds birds of the desert—the remains of all that has had life. It is by means of this action that the atmosphere and water regain perpetually that which the living world incessantly takes from them. They are the indispensable agents in the maintenance of life. But their function extends beyond this. They not only work at the destruction of dead matter, but they take possession of living organisms, sometimes producing local disorder, sometimes producing death. Thus the study of ferments is the study of the laws of health and disease; and the Authorities of the Health Exhibition have been very fortunate in securing for the treatment of the subject the eminent services of Dr. Duclaux.

Inasmuch as the intricacies of this and other hygienic questions can only be followed out by special methods of investigation, the Handbook on the Hygienic Laboratories is a fitting termination to this series, as it affords a view of the practical work which is necessary, and it explains the functions and the mechanism of one of the most important adjuncts to our machinery for regulating the health of the community. The Medical Officers of Health have had cast upon them in recent years numerous duties, such as the analysis of food, of water and of air, and the regulation of the disinfection of dwellings. These duties require for their performance extensive knowledge and delicate apparatus. In order that the attention of the public may be drawn in a practical manner to the intricate question of the cultivation of bacilli and microbes, as well as to the methods of analysing water, food, and air, the Executive Council of the Health Exhibition formed model laboratories under the supervision of accomplished authorities on these questions, viz., Professor Corfield, M.D. and Dr. Dawson Cheyne, M.D. These are matters of practical importance, which it is hoped will produce an effect in inducing all Health Authorities to furnish their officers with means on a proper scale for the efficient performance of their duties.

The series of Handbooks in this volume concludes with the very able and very useful treatise, by Sir F. Bolton, on the London Water Supply; the only remark which seems to arise on this work is that it should form the *vade mecum* of every London householder.

This brief sketch of the nature of the contents of the present volume sufficiently illustrates the extent of ground which a study of Hygiene, or the Art of Preserving Health, necessarily covers. The subject meets us at every turn. The neglect of Hygienic laws most surely visits the sins of the fathers upon the children; it leads to an enormous infantile mortality, to deformity, and to almost all the diseases to which we are subject.

When we consider the enormous amount of misery, of

disease and death, caused by this neglect; when we see how that neglect influences all our daily life; when we realise how much of our discomfort, ill health, and consequent poverty arises from the impure air in our rooms, from the dustbins in our back-yards, from the neglect of cleanliness in our persons, the want of physical training of our youth, the adulteration of our food, the permission which we accord to the sickly and to the criminal classes to transmit hereditary taints to future generations,—we may well feel astonishment at the complacency of the ignorance which produces this neglect. Laws and Government regulations may somewhat help the nation forward, but what is required is the education of the whole community, so that every individual shall know the meaning of a healthy condition of living; for it is only by means of public opinion that we can hope to enforce a high standard of health, and with it a high standard of happiness in the community. It is for this reason—because the International Health Exhibition has been a means of bringing prominently before the people the extent of the ramifications, and the important bearing of sanitation on daily life—that the British nation has reasons to thank His Royal Highness the Prince of Wales for having initiated the movement which marks so important an epoch in the history of sanitation in this country.

DOUGLAS GALTON.

ATHLETICS;

OR,

PHYSICAL EXERCISE AND RECREATION.

PART I.

BY

REV. E. WARRE, M.A.,
ETON COLLEGE.

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ATHLETICS;

OR,

PHYSICAL EXERCISE AND RECREATION.

Mens sana in corpore sano.

CHAPTER I.

INTRODUCTORY.

Importance of subject to national welfare—Athletics underrated—Overrated — True function — Individual — Social — Influence on character—Self-control—Fairness—Unselfishness—Good fellowship—Summary.

IN the motto so happily adopted for the International Health Exhibition, the right end and object of athletics, which we may define as physical exercise and recreation, is tersely and truly expressed. It would be hard to say how much that concerns intimately not only the happiness and usefulness of individual life, but also the good of society, and the future of the race, is involved in the right appreciation of the truth contained in this little form of sound words. They commend that which is as often overlooked by the enthusiastic advocate of intellectual progress as it is neglected by the thoughtless worshipper of physical prowess. They are a standing rebuke to those who would take one side only of human nature under their care, and leave the other to take care of itself.

Importance of the subject to national welfare.

"A sound mind in a sound body!"

or

"A healthy mind in a healthy body!"

Whichever translation we may prefer, it is plain that not one alone, but both together, should be the care of the educationalist and the legislator. Where the interests of either are overlooked, mischief will sooner or later follow, and though this may not in all cases be recognisable in the individual, it will not long be hidden in the community. Let mental training and culture be neglected, and there will follow in time a lowering of taste and tone, and a retrogression to that more animal type of life which is unlovely and undesirable. There will be less enterprise, less advancement in arts and sciences, less national progress, and, in the end, less national wealth. On the other hand, neglect the conditions of physical well-being, while stimulating mental exertion, and the consequences are certain. The brain overworked, while the other organs of the body are denied their proper exercise, will

"o'er inform the tenement of clay."

In the end it will have done less work, and have done that work less well, than it would have done if the due proportion of exercise and recreation had been observed and maintained. Nor does the evil in this case end with the individuals whose health and physical development have been thus impaired. The race suffers in consequence. The full results are felt by the children to whom they transmi[t] the feeble health and want of physical vigour, which th[eir] own faulty habits of life have engendered in themselves. [It] is the highest wisdom of all those who, as legislators, governors, or teachers, are responsible for the educa[tion] of the youth of the nation, to have due regard to [the] physical as well as to the intellectual needs of the you[ng].

"The babe unborn the dread intent may rue,"

of those who in their zeal for intellectual improvem[ent put] undue pressure upon tender brains, and overtax with [seden]tary hours and mental application the resources of [young] life. Whatever may be the drawbacks and danger i[n going] to the other extreme it is at least free from this per[il.]

who over-exert themselves in athletics bear their own punishment. They do not inflict any physical disabilities upon the next generation.

Athletics sometimes underrated, sometimes overrated.

It is not, however, the purpose of this handbook to hold a brief for athletic against intellectual exercise, but rather to point out, if it be possible, the means by which athletics may be made the accessories and companions of intellectual progress, of industrious vocations, and business life. Public opinion, in this as in other matters, is apt to oscillate between extremes. At one time we hear athletics vehemently denounced as the enemies of all mental improvement and educational progress. At such a time the unconscious Philistine is scourged and scarified by essayists and writers of leading articles, till the hands that wield the literary lash grow weary of belabouring the tough hide of the incorrigible. Soon the pendulum swings towards the opposite extreme. It is discovered that the world of English-speaking peoples is deeply interested in the result of a trial of speed between two crews on the Thames. New York and San Francisco, Cape Town and Calcutta, and even remote Hong Kong, are anxious to receive by telegraph the important news at the earliest moment. More than a million of human beings flock to see, or to fancy they have seen, the contest. The actors in it are the heroes of the moment; and the leading journal, conforming to the popular bent, devotes column after column of large type to the description of their doings. The whole thing is overdone. It is felt to be overdone; and then the pendulum begins to swing back again. Let us take advantage of the moment, when it has nearly reached the perpendicular, to plead for a right estimation of the value of athletics and to bring them under the limitation of the canon, "*mens sana in corpore sano.*"

True function of athletics.

a. Individual.

The truth is, that it is as easy to underrate as it is to overrate the value of athletics. In judging concerning them, it is necessary in the first place to distinguish between them and the excitement, often fictitious, that is set on foot about them: the betting, the gossip, the inordinate waste of

time in talking about and looking on at games and athletic contests. These are not in any sense athletics, nor do they deserve the name. By athletics we understand the healthy exercise of the physical powers, the necessary pastimes of a manly and vigorous race. Their true function, so far from being antagonistic to intellectual labour and progress, is to be its helpful associate. Rightly used, they are invaluable in this particular respect, and they cannot be discarded without a loss of vigour. They give increase of vital power and physical energy, in which the brain partakes as well as the rest of the body. Many no doubt pursue them unwisely for their own sake; but this does not make them less necessary or less advantageous to those who wisely engage in them for the sake of having a healthy body in which a healthy mind may do its best. Nor is it only by *exercise* that athletics confer physical benefits upon the individual who uses them rightly, but also as *recreation* properly so-called. Human nature requires change for its recreation. "Variety is charming," not only because it is variety, but because continuous effort in one direction produces lassitude, staleness, and decrease of power. By the law of our being change is necessary to prevent exhaustion and to restore vigour to the parts that, having done their share of labour, require the rest that they have fairly earned. Next to food and sleep, which are the great and necessary restoratives of physical power, athletics may claim to have the largest share in the recreation of human life. The man of business and the student alike find in them that variety and change from the regular work of life which refreshes and reinvigorates both mind and body. Each able-bodie individual, if he is wise, provides for himself both exercis and recreation in a way suitable to his age and powe with a view to preserving for himself a sound mind in sound body.

b. Social. But athletics have a still wider sphere than the indivi They need not be selfish or solitary. They flourish r as social in character, giving common occupation to m

similar needs and tastes, and thereby enhance their value to each and to all. They are in this respect of infinite importance to society at large, as providing for the gregarious instincts of human nature in the common pastimes of exercise and recreation. The multitudinous cricket, boating, football, bicycle, lawn-tennis, archery, and other clubs, that are spread like a network over the length and breadth of this land, are of more value to the life of the nation than most people imagine. They afford not only, as some affect to think, the outlet for animal spirits in harmless recreation, but a good deal more than this, viz :—the innumerable opportunities of intercourse between man and man, upon a common ground other than that of the business of workaday life.

4. Influence upon character. Self-control.

The influence that athletics thus exert upon the formation of character is enormous, and, in proportion as they are manly and conducted upon honourable principles, they exercise a power for good which is incalculable. They have always lessons of patience and endurance ready for those who will learn through them the way to success. They teach self-control. They are corrective of vanity. They discipline the temper. In a thousand ways the generous rivalry which is characteristic of wholesome athletics operates to the curbing of the hasty tempers and selfish inclinations of the individuals who take part in them. Even the fact that the circumstances of a game often call forth these frailties, and exhibit them in their unlovely proportions, has the collateral advantage of causing those to be more careful to exercise self-control and self-restraint who condemn in others the faults into which they feel that they themselves are liable to fall under like circumstances. At the same time such reflections tend to make them more tolerant and more ready to make allowances for the infirmities of human nature.

Fairness.

Again, the necessary demand for fairness in a game is in itself a condemnation of meanness and trickery in the individual. It fosters the chivalrous and generous element in humanity, and establishes among those who play a conscience

critical in such matters, which instinctively appeals to the standard of an honourable and upright character

Unselfishness.

It is difficult to say how great an influence for good such a feeling as this exercises insensibly, especially upon the young, in these days of self-seeking, when competition is so severe, and the struggle for self-advancement and self-aggrandisement is so keen and unremitting. To play well for one's side, or for one's club or school, without a thought of self, is a noble ambition, and he who does so sets an example which is felt and appreciated by his fellows, and is widely efficacious for good in others.

Good fellowship.

What good fellowship, what trusting friendships are cemented by social athletics! They test a man's real nature, they reveal his temper, and, along with his faults, his good qualities are not hidden. And, accordingly, they knit men together, not only in the bond of common pursuits and common memories of pleasant days and hard-fought struggles, but by the tie of mutual confidence which a thorough mutual knowledge gives to friends who have long played, or rowed together in the course of an athletic career.

We could hardly have better evidence of this than the words of one of Her Majesty's judges,* distinguished alike as an oarsman and a cricketer: "I feel, when I have rowed with a man, that I know him from head to foot. . . If I had to lead a forlorn hope, I should like best to have with me some of my old shipmates, some of the steady and trusty men who never failed in the supreme struggle of a University race."

Much more might be said upon this point, but enou[illegible] has been written to show that we can claim for athleti[illegible] rightly used, the honour of ministering to the "*mens san*[illegible] in many ways. They assist the intellect by supplying [illegible] best restorative and recreative for the brain, whi[illegible] the physical seat of the mental energy. They e[illegible] a moral influence upon the character, teaching p[illegible] and perseverance, self-control and self-restraint, cor[illegible]

* Mr. Justice Chitty. Speech at University Boat Ra[illegible] memoration Dinner, 1881.

vanity and self-sufficiency, and fostering a spirit of fairness and honour, a spirit also of unselfishness akin to patriotism. Nor does their influence stop at the individual. Socially they affect the life of the nation, and are directly of use in maintaining some of its noblest characteristics, moral as well as physical. This is a point to which we shall revert hereafter, believing that the benefits conferred by athletics upon the national life fully justify an appeal for facilities to be given to large classes of our countrymen who now know nothing of the better kinds of athletics, not because they have no leisure time to spare for them, but because either initiative, or place, or means are wanting. If these could be provided, many who now, after working hours are over, stand idling in the streets or sit in the public house, would be doing something better, viz.: maintaining the "*corpus sanum*" by healthy amusement.

The change of employment and the recreation afforded by a regular participation in games would invigorate many a life which now is stunted and enfeebled by the monotony of its existence. We should see a better colour, brighter eyes, a more elastic step, broader chests, and a more vigorous type altogether than is now to be met with in the growing male population of our large towns. Would there not also be a happier tone, less discontent, less misery; yes, and less crime? Or shall we be told that all this depends only upon the rate of wages, and the normal price of food?

CHAPTER II.

ANCIENT ATHLETICS.

Term from Greek—Greek idea of education—Gymnastic institutions—Ideal different in different tribes—Olympia—Deterioration of Greek gymnastics—Moral to be drawn—Roman athletics—Sole idea, health—Old and young—More practical than Greek—Deterioration—Effect on Latin races.

Ancient athletics. Term ahtletic from the Greek.

WE have already described athletics for the purposes of this handbook as "the healthy exercise of the physical powers, the necessary pastimes of a manly and vigorous race." But we are reminded that we are indebted for the term athletics to the Greeks, who were distinguished among the nations of antiquity in considering the education of the body as equally necessary with the training of the mind.

Greek idea of education.

The harmonious development of all the faculties and powers by suitable and regular exercise was the conception which at the best period of their history was dominant in their educational system. Hence, in their gymnastic institutions they did not lose sight of the fact that the mind is influenced through the training of the body. The end in view was the satisfaction in the best manner possible of the practical demands of life. And according as the qualities valuable in military or civil life were most in unison with the ideal of the tribe, so did the character of the education, intellectual as well as physical, vary The Spartan warrior was prepared for a life of painfu endurance by an education directed to the hardening c his body and the strengthening of his muscular vigo The Athenian, whose aim was grace and ease of bea and demeanour, found in his gymnastic exercises all t

Gymnastic institutions—ideal different in different tribes.

would tend to make him lithe and agile in movement, as well as erect and dignified in his general bearing. In the gymnasium and in the palœstra, running and wrestling, and boxing, together with the use of the bow and of the javelin, were the principal exercises of the youth. Contests of skill in these and other exercises followed as soon as the bodily powers had been matured; and any one who was pre-eminent in a particular branch had the chance of contending at the great gathering at Olympia, where once in five years, on the banks of the Alpheus, all Greece assembled to view or to take part in the national games. Great was the glory and the fame of him on whose brows the fresh olive wreath was bound by the judges. Admired of all beholders, honoured by his fellow citizens with many honours, held worthy of a statue by a Phidias, and of a hymn in his praise by a Pindar, he seemed to have reached the highest pinnacle of human success.

Deterioration of Greek gymnastics.

There were, however, evil and demoralising elements in Greek civilisation which led to the deterioration of their gymnastic education. By degrees it became professional rather than liberal, its aims were lowered, and the very name of athlete was brought, and not unreasonably brought, into disrepute. Apart from other considerations, it is evident that unless sustained by a high aim and lofty practical ideal the systematic training of the individual is apt to be brought down by selfishness and self-seeking to a lower level. The Greek athletics had not in them the collective element which is of so much value in our modern games, such as football and cricket. They rather exhibited what each individual could do for himself. Hence, as the national life and spirit degenerated, and as liberty faded away, the spirit also of the gymnastic education was debased. The athlete became that which the name implies, a mere competitor for prizes, and was often brutal and coarse, as well as stupid. He belonged to a class that was generally regarded as lazy, overfed, idle, and useless, and so he no longer found a Pindar to praise his victorious contests in deathless lyrics, or a Phidias to represent his

splendid symmetry in faultless bronze, but was rather the scorn of the philosopher and the butt of the satirist. He is responsible for a certain distasteful savour that clings to the name of athletics, and which even now half disposes us to wish that some other equally comprehensive term could have been employed as the title of a treatise, the object of which is to recommend these healthful exercises to the present and to future generations.

Moral to be drawn from this.

The moral is, that physical training and physical exercise should not be allowed to assume a selfish or a professional character, except so far as is necessary in the case of those persons who as teachers and trainers are obliged to devote their whole time to the work of instruction, and whose livelihood depends upon the same. The decay of pugilism and of professional rowing, though lamented by some, has in this respect a satisfactory aspect, and is not to be regretted when viewed in the light reflected by the history of Greek athletics. And yet, though there is no doubt that they had fallen away and were by his time far below the best ideal of the palmy days of Greek liberty, it is interesting to find in Lucian, himself a satirist, an apology for athletics in reply to the common invectives of the day. He insists upon their usefulness to young men in giving them some worthier objects of ambition than those which the indolence and effeminacy of the age would set before them, and in training and fostering those qualities and virtues which combine to make the character of the true "gentleman." Thus, though brought into disrepute by the evil habits of a class that lived upon them, the general usefulness of athletics, which could not be destroyed, preserved them as a part of education among the Greeks, even to the times of the late empire.

Roman athletics. Sole idea, health.

Roman ideas and practice with regard to games a athletic exercises were of a character very different fr those of the Greek. To the Roman, the whole ques was one of health. It seemed to him a necessary par regular and healthy mode of life, to take strong ex

causing perspiration before the daily bath which preceded his afternoon meal.

It was not a practice confined to the young, but was continued as late in life as the bodily powers permitted, and was accounted a duty, as well as a pleasure, even in a green old age. There was not the slightest idea of impropriety, when the consul or grave censor, or even the world-ruling Cæsar himself, sought in the game of ball, or other kinds of gymnastics, an exertion wholesome for both body and mind; and they who omitted such exercises were accused of indolence.* The famous lawyer and augur Q. Mucius Scævola is said to have been an excellent player at ball. Of all the illustrious men at Rome, Cicero is among the very few exceptions to the rule. Perhaps if he had played regularly, as the others did, he would not have been less illustrious, and might have been less querulous in his misfortunes, less vainglorious, less given to talk about himself, and so have spared us the pain of feeling anything but unmixed admiration for his true greatness and splendid genius. Beside the games at ball, which were of two or three different kinds, and were the favourite and commonest games in use among the Romans, they had a multitude of other exercises, some half military, some more, some less severe, all of which, however, were pursued by their several devotees with the same object, namely, a good perspiration followed by a bath, and a consequent good appetite for dinner. Riding, wrestling, running, leaping, throwing the *discus* or the javelin, were all in vogue. The Campus Martius was the scene of many an athletic contest, where the shouts of the ring (corona) hailed the feats of any doughty champion with tumultuous applause. Even the great Augustus himself, who gradually gave up riding, and even playing at ball, is described as taking his regular walk to and fro in such a way that just before he came to the turning-point he took a run and jumped. His little friend Horace, though obliged sometimes (as well as poor Virgil, who suffered from dyspepsia) to give up his game at ball

Practised by old and young.

* *Vide* Becker's 'Gallus.'

owing to his bad eyes, yet was a regular frequenter of the Campus Martius, and, if we may so infer from his mention of it, an expert in the *trigon* game, in which the ball was caught, and thrown by the left hand between three players.

Such were the games that the Romans themselves practised; and it is noticeable that they speak with unmitigated contempt for the Greek modes of exercise and amusement. They pursued their own in that same business-like and practical spirit which gave them success in other things. At the same time, we may remark that they also lacked the social element which is the characteristic of modern English games. Perhaps they had more of this than the Greeks; but with both the boat-races, to which we shall refer hereafter, seem to be the only athletic contest in which the effort was not that of one individual against another.

More practical than the Greek.

That the Roman ideal in the matter of athletic exercise was not so lofty as that of the Greek must be confessed; but, on the other hand, it was characteristically practical, and the doctrine that it was everybody's duty to get an appetite for dinner in this particular way was, if homely, yet of daily cogency, and well calculated to form regular habits.

Deterioration.

It was only when the infusion of Greek and Oriental corruptions had destroyed the greater simplicity of Roman life, that these energetic daily exercises made way for a more easy and indolent style. The change was not without its effect upon the national character. What would a Cato or even a luxurious Mæcenas have thought of the loose and effeminate habits of the Roman nobility in the degenerate days of the decline and fall? Apart from other influences, the constant spectacle of gladiatorial combats, or of the beasts glutted with human flesh in the amphitheatre, and the horrible pleasure derived from such sights, as they became more and more common, must have gradually engendered habits of thought and feeling alien to those with which a manly and vigorous spirit is sustained; and it is not

wonderful that when these horrors were stamped out by the beneficent influence of Christianity, they left the Roman race and those subject to it in an enervated condition without that daily habit of hard exercise which had been the source of so much personal vigour to the conquerors of the world.

Effect on Latin races.

Can it be owing to this that the Latin races in Europe at the present time have so few games in which physical exercise is taken? The old Roman game of ball seems to have a survival in a game which is still played in parts of Italy, and in the French "jeu de paume" (pila palmaria), which was extremely popular in the middle ages. Possibly tennis is also a descendant of the same original stock, though the present form of the game is, if the story be true, due to accidental and originally local causes, just as the Eton fives game owes its peculiarities to the stairs and buttress of the old chapel. But with these exceptions there do not seem to be any games that deserve the name of athletic on the Continent. Gymnastic exercises there are, and military training enough and to spare, but these do not in any way represent ancient athletics, or fulfil the same office as the social games which are the proper pastimes of youth in "merrie England."

CHAPTER III.

DEVELOPMENT OF ATHLETICS IN THE INDIVIDUAL.

Craving for exercise in human nature—The infant—Sensorial motion—The growing child—Fidgets—Love of change—Beginning of education—Need of care and discrimination—The whole being to be considered—Boy life only treated of here—Change to school-life—Private school training—Competition—Play and work—Loafers—Athletics of school life—Gymnastics no substitute for games—Certain exercises compulsory—Record to be kept—Punishments—Public school—Mature life—Misuse of athletics—Neglect—Training necessary for any great effort.

1. Athletics: craving for in human nature.

BUT in order to trace the origin of athletics, if that is germane to our present purpose, we shall have to go further back than Greece or Rome, or even the still higher antiquity of Egypt. The truth is, that the craving for exercise is a part of healthy human nature. The very cries that the infant utters when it first enters into this world, are the first exercise of the lungs in the ex-

2. The infant.

pansion and contraction necessary to life. The waving of the tiny hands, and the kicking of the little feet, in seemingly meaningless and aimless motion, are the means whereby the circulation of the blood and the nervous action necessary to growth and expansion are maintained. Each action is accompanied by waste of tissue, which boon nature replaces, with interest and accumulated energy, in the healthy body. There is pleasure in this to those who watch with a mother's pride the vigorous effort and the signs of growth and health in their offspring, and that there is innate pleasure in the action itself is testified by the dimpled laughter, and the crowing of the infant animal life.

3. Sensorial motion.

The sensorial motion which agitates the limbs of the

young is the hidden cause of the first physical exercise—in a word, of infant athletics. The more vigorous the animal life the more constant and pronounced is this play of the limbs. Here is the beginning of games and of all athletic exercise! What cruel misconception first invented swaddling clothes? We remember seeing some years ago in Southern Europe, in a cottage among the hills, an infant tightly bound in these abominations on a board which projected above its head, hanging on a peg like a picture against the wall. It seemed monstrous cruelty. Our first impulse was to take it down and release it, but it was the custom of the country, and as such could not be interfered with by strangers, however benevolent.

As growth progresses the bones are gradually hardened and the framework knit together more firmly; and still, as in the case of the great orator, so for the perfection of nature's plastic masterpiece, action, action, action, is necessary. The growing child finds this in play; if not allowed to play he fidgets. Fidgets are often provocative of wrath in his elders. One often hears a child scolded in a somewhat angry tone: "Why can't you sit still?" It would be better if, instead of feeling annoyed, "Corrector Bestius" returned answer to himself, "The child can't sit still;" nature in fact does not intend him at present to do so. She is stimulating him through his nerves for the sake of his growth. He is not fidgeting through *malice prepense.* He is not doing it on purpose; he may indeed control it by an act of his will; but the thing itself is involuntary; and it is very doubtful whether, on most occasions, he should be called to stop it by a direct act of his will. It may in some cases be good discipline for him to do so, but a person who understands children, and loves them, will generally succeed in abating the nuisance without making any such demand. The objectionable fidget arises from lack of other employment congenial to the moment Supply this, or divert the attention to something that interests, and the nerve centres will have work to do, and the physical need be satisfied.

4. The growing child.

a. Fidgets.

b. Love of change.

It is interesting to observe that the delight in novelty, and the quickness with which children change from one thing to another, the very fickleness with which they drop that which pleased them for the moment, is unconscious obedience to the law of nature, which requires change as a means of resting one set of muscles and nerves, and of giving employment to another set in its turn. The very joy which they express is the outward sign of their obedience to the natural law. As they grow older they become capable of more sustained effort, and less ready to change, but the divergences of taste and of ability which differentiate the character are in themselves the evidence of the variable amount in which, in different individuals, according to either hereditary disposition or difference of food or other circumstances, the tissues have been used and replaced with interest during infancy and early childhood. The consequences of mismanagement and of illtreatment during this period are far-reaching. Many others beside Mephibosheth have suffered in body till the day of their death, owing to the carelessness of their nurse. How many have suffered mentally and morally even worse things from the same cause, or from the ignorance of the truth of nature and the simple rules of health on the part of those to whom they, body and soul, were entrusted!

5. Beginnings of education.

As the child grows older the need of education is recognised, in view of the future and the practical demands of life. Lessons begin. The brain has its allotted tasks to perform; and so in many cases a kind of conflict begins together with lessons. To some in whom the sensorial action is vigorous lessons are more irksome than to others; they are very often called naughty. Their athletics are ill-timed, and it must be confessed provoking to those who desire to do their duty in the way of teaching. Others are ready enough to take to books, and like being taught, and are quick and receptive of knowledge; but in many instances these show a distaste for any but the smallest and easiest amount of bodily exercise. They prefer sitting in, and dislike going out. How careful, how discriminating should

be the treatment of children, varying as they do in capacity and power, mental and bodily! All need lessons. All need exercise.

But how much care is necessary on the part of those who have to superintend either or both of these! How particularly careful they should be not to overstrain the tender growth by imposing or allowing that which is contrary to the requirements of nature—not the nature of the body or of the mind only, but the nature of man who has both! Nurses and governesses are often unconsciously torturers. Children are made to take long walks, or to sit too long at lessons, and the powers and inclinations of their elders are perversely made the measure of what is good for them. The results become apparent later on. In some is bred the dislike of active exercise, in others an absolute distaste for any mental exertion. Extremes meet; and similar results follow that indulgence which is foolish in yielding when it ought not to yield to the childish desire to go out or to stay in, to leave its lessons unfinished, or to sit poring over a book, or dreaming and doing nothing at all. These things vary infinitely in different individuals. It needs a wise and discriminating parent to determine the *régime* suitable to the child of his love. Much has already been written and much no doubt will be written upon the subject of early education. It is doubtful whether much can be learnt from books upon the question. **6. Need of care and discrimination.**

But one thing, at least, is certain, that no system can be satisfactory, much less successful, which does not provide for the healthy training of the whole being of the child, dividing and distinguishing mental and bodily exercise if it will, but at the same time co-ordinating them in due relations to each other, and providing by elasticity of method for the diversity of ability and inclination with which it has to deal. The aim and object of right education, whether early or late, must be the "*mens sana in corpore sano.*" **7. The whole being, not mind or body apart, to be considered.**

But we shall be accused of wandering from our subject, and of having quitted the athletics of the perambulator and **8. Boy life only treated of here.**

the schoolroom for the graver and wider subject of general education. We must hurry back to our task of tracing the history of athletics in the individual as he develops, and we have now come to the momentous period in the life of the growing boy when he leaves the home care, with all its comfort and indulgent restraint, for the very different discipline of a private school. We are speaking of boys only, in connection with this subject of athletics, not because we think that athletics according to our definition are alien to girl life and belong to boy life alone, but the two differ so much in character that it is more convenient to treat of the subject in relation to the other sex in a separate chapter.

9. Change from home to private school life.

The boy passes to a school, and a considerable change takes place in the habits that are enforced upon him, both bodily and mental. He may have had brothers and sisters to do his lessons with and to play with, but even so the main change in his condition is that the social element now for the first time enters into his athletics as well as into his lessons. He competes with his superiors, equals, inferiors in body and in mind, in his play and in his work. The consequence is, as a rule, a higher tension in both. Individuals vary infinitely, and according to capabilities and disposition. So does the play and the work of the school affect them. Here, as before, we may pause to exclaim, "How great a responsibility is theirs who undertake the care of boys between the ages of, say, eight and fourteen!"

10. Objects proposed in private school training.

What is the object that they propose to themselves in relation to the training of these children? Is it success as measured by the number of scholarships that the school can gain at the public schools? or the number of boys that are placed in the highest form possible on entrance? Or is it that care of the boy which without much solicitude about mental advancement exhibits him well kempt and cared for, as regards his bodily exterior, to a fond mother, who will say perhaps to her friends, "Well, I am afraid that my dear boy does not know as much arithmetic or Latin grammar as he ought to know, but then, you know, Mr

So-and-so's is an excellent school. He is so very careful about the health of his boys, and health, of course, is the first thing." "Yes, madam," we would rejoin, "health; but the health of the whole boy, not of his body only; and I am not sure whether your son, who has been coddled at home, and, after that, coddled at school, can play at anything, any more than he can work at anything, at present."

Happily for the boys of this generation, there has been a wholesome reaction from the hardness, and carelessness, and neglect of comfort which characterised schools forty years ago. Some schools, as might be expected, have gone into the opposite extreme. Yet, at the majority of the private schools which prepare boys for the public schools, the boys are well cared for as regards their creature comforts, if coddling is avoided, and in not a few they are extremely well taught. And here it is that the subject of athletics comes in, and is of very real interest. Such is the competition for scholarships and entrance exhibitions nowadays, that the pressure upon many boys between the ages of nine and fifteen is extreme, especially upon those who show any mental ability. Every year at the greater public schools from eighty to one hundred candidates are standing for entrance scholarships and exhibitions. All that we are here concerned to ask in the case of these boys, is, Has the canon "*mens sana in corpore sano*" been duly regarded? It would be (and at the best private schools it is) well understood that the interest of the master extends to the play of the boys as well as to their work. How needful for the brain which is of finer fibre and more delicate texture, capable therefore of higher intellectual effort and of achieving intellectual success, that the rest of the body—heart and lungs, and limbs—should be looked after in its interest, or rather in the interest of the whole being! Such an one needs all the play and the exercise he can be induced to take, and should be carefully trained, not with any precise gymnastics, which have very little of the joy of life in them, but with games in which he should be drawn if possible to take interest by encourage-

11. Competition.

12. Play and work.

ment and kindness. At any rate, if he cannot be prevailed upon to play, care should be taken that he has open-air exercise in due proportion to his powers and with the view to develop them.

13 Loafers. There are, we are inclined to think, very few boys who could not be induced to play at games, but as a matter of fact there are a great many who do not play except by compulsion. Some of these are students by nature, and prefer mental work to bodily exercise. But many of those who do not play do not work, except upon compulsion. These are they who are called by their more vigorous contemporaries "muffs." These furnish recruits to the large army of "loafers," a host which in point of mere numbers exceeds, we suspect, that of the energetic workers, physical and intellectual, put together. These are they whom home education has spoilt, and the private school education, if they have had it, failed to recover. These furnish spectators to any games which require pluck, endurance, and self-control, but not the actors in it. Theirs is the endless gossip and do-nothing excitement and gaping idleness, which a great many excellent persons persist in confounding with athletics, with cricket, and boating and football, of which these worthies are all but guiltless.

14. No antagonism between good work and good play. It should be the object of a school to produce as few as possible of this type. It is not pretended here for a moment that boys who play well always work well, or are always fond of their lessons. A great many do work well as well as play well, more than it is the fashion to suppose. There is no antagonism between good work and good play, any more than there is between the "*mens sana*" and the "*corpus sanum.*" The two are quite compatible. But there are many who are mentally slow, and physically vigorous, who rejoice in their games, but do not find the same joy in their lessons. These not unfrequently, though they may not shine in literary pursuits, find it difficult to pass any of the examinations which now like three-headed Cerberi guard the portals of most professions; yet, if they do pass, are found not to be a whit inferior as public

servants, as soldiers, as clergymen, or in any other profession, to their fellows, and often discover in the work of life, in the business of their profession, qualities of the highest value, the existence of which in them the examiner who looked over their papers, and perhaps just did not pluck them, could scarcely have divined. It should be the object of school teaching as well as of school discipline to look after the interests of the "*mens sana*" in these, and to keep up the standard of their intellectual work. This will not be done wisely by curtailing the amount of out-of-door exercise that a vigorous body requires, but rather by seizing on the times when talk, rather than work, of any kind is rife; by making the hours due to preparation of lessons to be really employed in the work; above all by kindness and encouragement, analogous to that which we said before should be extended to those who dislike playing at games, and by as little punishment *quâ* punishment as possible.

15. The athletics of school life.

And here we reach the important and somewhat formidable question, what should be the athletics of school life? Chiefly and primarily the ordinary out-of-door games; these should be as free as possible from the compulsory incidents which make them absolutely distasteful *in limine* to the weaker ones. We shall speak of athletics at public schools and universities more particularly hereafter, and will here confine ourselves to the athletics of younger boys. Cricket and football, fives and rounders, and prisoner's base, all in their season provide for vigorous boys the amusements they require. Everything possible should be done to encourage the weaker ones to take their part in these games, to endure a little hardness, and to play their best.

16. Gymnastics, but not substituted for games.

But there are some things which do not belong to the category of games, which might well be insisted on in the training of individuals, being good for the development of the physical powers. The young Augustus ought not to neglect in his youth that which his imperial namesake thought necessary for his health even in advanced life.

Running and jumping should be a regular part of school training. Besides a good stout rope for "tug of war," parallel bars, and the vaulting horse, not too tall for little boys, are all the gymnastic furniture that a school requires. The use of them is easily taught, and the exercises useful in kind. As for gymnastics technically so called, we do not advocate them as desirable for boys at school. They are useful for young men at the university, who, conscious in themselves of lacking physical development, voluntarily undertake the course. But in them the professional instructor's presence and guidance is necessary, and they should not be entered upon without such supervision. They are very desirable for young soldiers, and for men whose physique requires development for the better performance of their duties. But at school, if compulsory, they are apt to interfere with that free and natural development which the joy of a game alone can give, and it is doubtful whether the system is not too artificial to be quite in harmony with nature in the process of development. Any substitution of technical gymnastics for games would be a great mistake. Even if the body, which is very doubtful, would in any way be permanently a gainer thereby, there is no doubt that the mental and moral being would lose enormously. There is always some little difficulty in teaching chickens hatched by an incubator to pick up their food in the natural way, and such is the entirely artificial character of a strict gymnastic system, that, even if it was successful in turning out a large number of boys with the nerves and sinews and muscles of acrobats, it would not have supplied them with those qualities, moral and physical, which in the English lad are nurtured and brought to perfection in his games.

17. Certain gymnastic exercises compulsory.

At the same time, there are certain exercises which may be said to belong to the gymnastic course which we would advocate as compulsory beside the running and jumping above mentioned. These are the extension motions and elementary drill. Without being violent exercise they tend to set up the body and expand the chest. They should not

be continued too long at a time, especially with the younger boys. A short half-hour every morning should suffice for this compulsory training in physical exercises, viz. running, jumping, extension motions, drill, which should alternate and be carefully graduated so as to suit the powers and health of the boys.

It cannot be too strongly insisted on that, weather permitting, all boys' exercises and games should be conducted in the open air.

Ten hours for rest, seven hours for work, seven hours for meals and recreation, is a fair division of the twenty-four hours for young boys.

18. Record physical growth and development.

At all schools a book should be kept in which should be entered the name of each boy, with the record of his growth, height, measurement round the chest, and weight at the beginning or end of each school-time, his age in years and months being also correctly given. These tables, if regularly and accurately kept, would be invaluable as statistics in many ways. A form is appended which might be found useful for the purpose. (See pp. 31, 32.)

19. Punishment.

And here we would add one word about the difficult subject of punishment. Of corporal punishment we say nothing. Solomon's advice is not in favour in modern times. But it is much to be feared that the punishments inflicted on boys in many cases rob them of the amount of time that they ought, for their physical well-being, to spend in the open air, and that without doing any good to their minds. At a private school might not punishment drill or walking exercise sometimes be substituted for the other alternative of sitting in at a desk and writing an imposition? Boys would dislike it as a punishment, just as much or more, and they would thus be made to feel their fault without any detriment to their physical life. Pains should be taken on all hands to reduce punishment to the minimum compatible with good discipline and industry. There is a wise sentence in one of the Latin exercise books which all teachers may well lay to heart. "Do you find fault with yourself as often as you inflict a punishment on any one else?

20. Summary. We believe that if the physical exercise and recreation of boys at private schools were the object of such care as has been indicated above, not only would the intellectual standard not be lowered, but the quality of the brain work would be improved. We certainly should see fewer cases of those who, suffering from the pressure of preparation for a competitive examination between the ages of nine and fourteen or fifteen, are in the years that succeed stale and listless, and unable to work up to the standard to which as picked boys they ought to attain. We should, we believe, see fewer "loafers," and more of those healthy and vigorous specimens who exhibit, to the credit of those who have had the care of their education, "a healthy mind in a healthy body."

21. Change to public school. But life moves on and the boy quits the private school, and probably enters the larger world of a public school, and finds in that larger world more freedom and a wider choice of companions and pastimes. Great as is the change, the habits of this previous life will accompany him and will silently determine much of his career. In some respects he will be much more his own master, and if inclined to do nothing in the way of physical exertion will be able to do a minimum. The rules of the house or of the school may compel him to play at this or that game so many times a week, against his will, but he will not energise much if he only plays on compulsion, nor will he get much good from the game. If, on the contrary, he is keen to play he will find ample opportunities of coming to the front, and ample delight in the exercise and the interest which the contest of skill or of speed and endurance brings with it. And as his frame is knit together and his power increases so will his pleasure increase, and the wholesome ambition for distinction among his schoolfellows. And if he is conscientious, and works well as well as plays well, his pleasure and profit will be all the greater. Brain will help nerve and muscle, and nerve and muscle will help brain. And if he takes part in important contests in which he may with others be representing his house or his school, he will soon learn the

RECORD OF

PHYSICAL PROGRESS OF PUPILS

AT ____

DIRECTIONS FOR USE OF TABLES.

1. Each name should have a page to itself.

2. Entries should be made at the beginning or the end of each term, or oftener, at regular intervals.

3. Height, in feet and inches. Taken in stockings or bare feet; no boots on.

4. Chest measurement in inches. Hands above head, arms extended, thumbs crossed, palms turned to the front. Pupil to take full breath, and then count ten, aloud, slowly. Measurement taken with last number, over bare chest, or thin jersey only.

5. Weight, to be taken between 8–10 A.M., as a rule. Take off coat and waistcoat, and boots, and anything heavy out of pockets.

6. Remarks. Under remarks any serious illness or accident interfering with progress should be noticed.

7. Averages. It would be useful, at the end or beginning of each term, or annually, to take aggregate—

(1.) Number of pupils.
(2.) Aggregate years, months.
(3.) Aggregate (i.) height.
　　" (ii.) chest.
　　" (iii.) weight.
(4.) Divide the aggregates by number of pupils, and the normal figure for the school will be obtained.
(5.) Take total number of boys within certain limits of age and divide by that number their aggregates within those limits, and normal rate for age will be obtained.

RECORD OF PHYSICAL PROGRESS.

Name .. .. Born .. ..

Hair .. .. Eyes .. .. Came .. ..

Complexion .. .. Left .. ..

Date.	Age.		Height.		Chest.	Weight.	Remarks.
	Years.	Months.	Feet.	Inches.	Inches.	lbs.	
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							

value of self-control in play and of self-denial. As a preparation for it, the maxim "be temperate in all things" will not be alien to his life. He will learn many a lesson, not without suffering something, not without enduring hardship, which will be found not less useful than his studies themselves in the game of life.

But as we shall revert to the subject of athletics at the public schools and universities, we will pass over this stage briefly here, and glance onward to the question of physical exercise in mature life.

The boy becomes a man, and the age of play comes to an end, and the age of real work begins. This is true physically, as well as practically. The growth completed, there is no longer existent the condition in which nature was adding, with compound interest, for tissue wasted in wholesome exercise to the body she was building up to manhood. The frame now becomes little by little more set, and little by little loses in agility what it gains in solid strength. True it is that, even now, nature will give interest in a healthy body for active and violent exercise of particular limbs or muscles. She will fill out the biceps and fore-arm of the man who wields the blacksmith's hammer She will keep hard and solid and in good condition the thews and sinews of one who takes suitable hard exercise every day, and is careful about his diet. But the sensorial motion is no longer active as in the child. If a grown-up person is a fidget, it is either owing to some nervous defect, or to an inveterate uncorrected habit or trick, and may be looked upon as a thing to be endured, for it is not likely that it will be cured. As time goes on little by little in most men the delight of hard exercise passes off. If their business entails upon them a sedentary life, amid the growing cares and anxieties of work occupying the thoughts, the tendency to drop violent exercise, except perhaps at first during the annual holiday, will surely gain upon them. With many men it soon becomes irksome to take any exercise beyond that which in the course of business they are forced to do in the moving from place to 22. Mature life.

place. With many, such exercise as they do take has in it more of duty than of pleasure. No doubt at first the age of play and the age of business overlap each other. Happy the young man who, bringing from school or college to the business desk a healthy body and a healthy mind, maintains as long as he can the habit of healthful exercise suitable to his powers. Happy the City clerk who can, after business hours, get on his bicycle a good lung-filling draught of pure country air. Happy he who can go down to Putney or Kingston, and get a good spin on the river in his club eight or four. The time of course will come when he will have to give this up, but as long as he can do it and feel all the better for it, so long he should resist the inevitable conclusion that will be forced upon him some day or other that it is too much trouble, that he cannot afford the time, and the like. Wise is the man who, when his time comes, and the love of ease is gaining ground, yet still refuses to drive into the City in the morning, and walks in and walks out to his place of business from his house or from the station, and continues to make his legs do their duty towards keeping his body healthy. It has been said that a man under five-and-forty, in order to keep his body in sound health, ought to take exercise equivalent to a walk of nine miles every day. Very few men, we suspect, except such as by their occupation are compelled to lead an out-of-door life, regularly do anything amounting to this. Yet it is well to have a standard of comparison. It is well also to have a clear conception of the reason for continuing such physical labour at a time when the inclination to spare himself trouble is gradually growing upon a man. The exercise is for the benefit of heart and lungs and brain, and for that which is life-sustaining in them. It is recreation and rest to one class of muscles and nerves, while it gives their due share of vibration and expansion and contraction to another.

The athletics of infant life were, as we saw, involuntary, but it often requires a strong effort of will to maintain

the due proportion of athletics as years advance, but we believe that if the example of the ancient Romans was more generally followed in this particular respect, we should have fewer early collapses, fewer hypochondriacs, fewer dyspeptics, fewer pallid faces with pendant cheeks, fewer fatty, unwieldy figures, more vigorous, generally healthy bodies, and certainly not less generally healthy minds.

23. Misuse of athletics. *a.* Waste of time.

But it may be replied, "Granting all that you claim for athletics rightly used, granting even that they are not the antagonists to work and mental industry that they are very generally supposed to be, even you will admit not only that it is possible to misuse athletics, but that as a matter of fact they are frequently misused." We are not quite sure as to the reply to be given to this assertion, until we know what is meant by misuse. We will admit that if a man goes to row on the river when he ought to be at his desk in the City, he is in a sense misusing athletics, but the man, and not athletics, should bear the blame in this case, just as much as if he was playing at billiards, or stopping in bed and reading a novel, or doing anything else that pleased him instead of doing his duty. This is not that kind of misuse against which we are specially concerned to warn him in this handbook. "Duty before pleasure" is the rule of the "*mens sana in corpore sano*," and if he neglects this rule, he must bear his own burden.

_b._ Over-taxing of powers.

But there are certain misuses of athletics against which we are bound here to lift up our voice.

First, with regard to boys. They are very apt to misjudge their power. They will attempt to do things out of proportion to their strength, whether in running, or in lifting weights, or in putting the stone, or in performing feats for the sake of admiration, or to outdo somebody else. They therefore require some watching and care in this respect on the part of those who have charge of them, and that not in such a way as to discourage them from progress according to their strength, but to prevent them

from doing things either beyond their strength, or in the wrong way.

Lifting weights. For instance, a boy trying to lift a weight which taxes his strength will almost always, unless set right, stand in such a way as to throw an undue strain upon his abdominal muscles, and run the risk of straining and perhaps rupturing himself. The exercises which are technically called "Athletic Sports" are often fraught with danger of this kind, especially for young boys. They are tempted to perform "*tours de force*" which are beyond their muscular strength. The effort is sudden and violent, and so strains often occur which sometimes entail serious consequences even in after years.

Trials of speed. The same thing may be said with regard to trials of speed, flat-races, hurdle-races, and the like. The heart may easily be overtaxed by the individual being tempted to sustain violent exertion beyond its powers; even if it is naturally strong and healthy, a very sudden and violent effort, or a strain unduly prolonged, may do it damage.

c. Neglect. Catching cold. Again, the spring is the time of year when these sports are most in vogue. It makes one shudder to see boys stripped, with only a thin jersey on, and flannels cut off at the knee, either waiting for their turn to compete, or, having competed and having got thoroughly heated with exertion, stand and look on at the next performance in a cold east wind. One might multiply instances of similar imprudences, of which neither "*sana mens*" nor "*sanum corpus*" should be guilty. But boys will be boys, and it is well if their elders are on the look-out, and ready to protect them against themselves.

24. Necessity of supervision in case of boys. On the other hand their elders are sometimes tempted to misjudge the extent of boys' powers; "*La jeunesse n'a jamais tort*," a proverb which is not unfrequently falsified, seems true in their eyes. Let them alone, they can't hurt themselves, say they, when perhaps a word in season would save from years of pain or ill-health.

In carrying out the exercises or the drill recommended above, it cannot be too strongly impressed upon instructors

that they should not be continued for too long at a time; frequent rests should be given, during which the reason of the thing may be explained and elementary instruction as to the structure and various functions of particular muscles may be conveyed, which will interest and benefit boys while filling up the interval of standing easy. Nor ought the warnings at such time against straining themselves by attempting foolish feats, and against getting unnecessarily chilled before or after running a race, or the like, be left unsaid. Many boys do foolish things of this kind from ignorance, innocent, but not innocuous. "All unconscious of their doom the little victims play." But as there is no particular bliss in this kind of ignorance, it is as well to try and infuse a little wisdom of a practical kind which may perchance save them from such folly and its fruits. Bigger boys and young men who have got beyond any supervision of the kind need to be warned by those who have experience in the class of athletic exercise to which they are devoting their energies, and to whom they naturally listen with some respect, that for many efforts, and especially prolonged efforts in competition with others, a course of training is necessary. Of this we shall speak at length in a subsequent chapter. But we may say here generally, that athletics are misused when heart and lungs and other muscles are asked to do that for which they have not been prepared. The brain usually refuses an intellectual effort which is beyond its power. It soon becomes bewildered, will not go on, for instance, with an arithmetical puzzle which is beyond its capacity. It may indeed be overstrained by a prolonged effort. But it is not often called upon suddenly to perform such feats as in the ardour of an athletic contest, or on the spur of the moment, are ruthlessly demanded of the heart and lungs. This is a real danger, against which the young and ambitious athlete needs to arm himself with the counsels of prudence and self-restraint. Lastly, those who are suffering from a cold affecting throat or lungs, or those who are convalescent from an illness, and have not yet regained full bodily health and vigour, should not attempt

25. Training necessary for any great effort.

exercises which are healthful only for those who are perfectly sound. Ill results have come about to many from these seemingly obvious rules being violated. These, and there may be other misuse of athletics, are for the most part cases of imprudence. Against them the true antidote is common sense, that "*mens sana*" which should keep watch and guard over the "*corpus sanum.*"

CHAPTER IV.

ATHLETICS, SOCIAL.

Social character—Peculiarly English—Contrast with foreign ideas—History of English athletics to present time—Development of social athletics—Causes—Mostly restricted to upper and middle classes—Multiplication of clubs and matches—Healthy aspect—Unhealthy symptoms—Decline of professional athletics—Desirable that social athletics should be developed among the lower classes.

1. Athletics, social.

IN the foregoing remarks we have, while sketching the history of athletics from childhood upwards, dwelt chiefly upon them so far as they affect the individual, the part which they play in this physical development and in the recreation of his mind and body. But as we had previously pointed out, athletics have a wider sphere than the individual. They are for the most part social in character, and as such exercise a very wide influence on society at large, and upon the youth of the nation. There is something peculiarly English in this feature. Indeed it would not be true to say the same of any other nation. There is no particular in which the English race exhibits so strong a contrast to foreign races, as in its ardent love for games of which violent bodily exercise is the characteristic. Wherever a colony of Englishmen is settled, it must needs have, even in a hot climate, its cricket, its rowing, its polo, or even its football. Its proceedings in this respect seem to foreigners mysterious, strange, and even bordering on the insane. They cannot understand the enthusiasm of the players, the violent energy expended, the endurance of contusions, and the general good temper displayed under circumstances which would rouse hotter blood to fury.

2. Peculiarly English.

3. Contrast with foreign ideas

A distinguished Frenchman, one who knows England and the English better perhaps than any other French writer, thus describes the favourite games of an English public school: "Au ballon les groupes se précipitent les uns sur les autres; l'enfant qui se trouve dessous porte le poids de toute la masse; il y a des bras et des jambes luxés, des clavicules cassées. Au cricket la grosse balle pesante est lancée avec tant de force que le joueur maladroit est renversé, s'il s'en laisse atteindre. Presque tous les jeux comportent habituellement des meurtrissures; on se fait gloire d'y être insensibles, et, par une conséquence naturelle, on n'hésite pas plus à les infliger qu'à les subir." (Taine, 'Notes sur l'Angleterre,' p. 144.) The games are evidently in his eyes brutal and brutalising. He can see nothing of their skill, he knows nothing of their joy. They are, in their spirit and power for good, quite incomprehensible to him. We remember some years ago, in conversation with a professor at one of the great Lycées in Paris, after discussing the modes in which English and French boys spent their play-time, and the great difference between the two systems of education with respect to liberty, that the game of football was alluded to, and at his request described. His remark in reply was, "Chez nous ça serait impossible—serait une émeute." At the same time he regretted that it was so, and did not conceal a wish that the youth of his country could be more habituated to games in the open air, and entrusted with more liberty in their amusements than at present is the case. M. Taine, notwithstanding his unfavourable comment on cricket and football, expresses himself in a somewhat similar manner. "L'écolier français, surtout l'interne de nos collèges, est ennuyé, aigri, affiné, précoce, et trop précoce; il est en cage, et son imagination fermente." And he confesses that as regards the formation of character, the education of an English school is better. "Elle prépare mieux au monde et fait les âmes plus saines." There are not wanting among his countrymen, now that England is better known than it was to them,

many who would like to make an approach to the English type in the education of their scholars, so far as outdoor exercise and games are concerned. It is, however, very doubtful whether any such experiment would be successful. At any rate it would take a long time to acclimatise.

The fact is, that this love of games and violent exercise is characteristic of the English race, and a matter of hereditary custom. **4. History of English pastimes.**

According to Strutt, "though perhaps the skill which the natives of Devon and Cornwall retain to the present day in hurling and wrestling, may properly be considered a vestige of British activity, yet the Romans enervated the spirit of the people by the importation of their own luxurious manners and habits, so that the latter part of British history exhibits to our view a slothful and effeminate race of men totally divested of that martial disposition and love of freedom which so strongly marked the character of their progenitors; and their amusements, no doubt, partook of the same weakness and puerility." **British.**

It is to our Saxon ancestors that we owe our national love of games and robust exercises. In turbulent times, when the rule was "that they would take who have the power, and they should keep who can," it was natural that such exercises as inured the body to fatigue and biassed the mind to military pursuits, should have constituted the chief part of a nobleman's education. Accordingly, we find that hunting, hawking, leaping, running, wrestling, casting of darts, and other pastimes which necessarily required great exertions of bodily strength, were taught them in their adolescence. The Norman Conquest does not seem to have caused any change as regards popular sports and pastimes. The conquerors introduced jousting and tournaments, and restricted the practice of hunting by severe forest laws. According to Fitzstephen, who lived in the time of Henry II., the young Londoners of that day exercised themselves with archery, fighting with clubs and bucklers, and running at the quintain; and in the winter **Saxon.** **Norman.**

when the frost set in they would go upon the ice and run against each other with poles, in imitation of lances, in a just, and frequently one or both were beaten down, "not always without hurt, for some break their legs and some their arms; but youth emulous of glory seeks these exertions preparatory against the time that war shall demand their presence."

Decline of military exercises.

With the decline of chivalry and the subsidence of the military enthusiasm which so strongly marked the middle ages, came also a change in the character of the popular games. The exhaustion of the national vigour in the long and destructive conflicts of the Wars of the Roses manifested itself in the neglect of military exercises, and in the growing popularity of such games and recreations as promoted idleness and dissipation. This prevailed to such an extent that even the interference of the legislature from time to time was thought necessary to "correct the bias of the common mind."

Tudors.

Henry VII. and Henry VIII. both made efforts to restore the practice of military pastimes. The latter set the example in his own person, "continuing daily to amuse himself in archery, casting of the bar, wrestling or dancing, and frequently in tilting, tournaying, fighting at the barriers with swords and battleaxes, and such like martial recreations, in most of which there were very few who could excel him!"

Stuarts.

There is a remarkable passage in the ΒΑΣΙΛΙΚΟΝ ΔΩΡΟΝ, or 'King's Christian Dutie towards God,' written by King James I. for the instruction of his son, Henry Prince of Wales. That learned monarch seems to have been of the same opinion as M. Taine regarding football and violent exercises. Otherwise he is not averse to games. "Certainly," he says, "bodily exercises and games are very commendable as well for banishing of idleness, the mother of all vice, as for making the body able and durable for travell, which is necessarie for a king. But from this court I debarre all rough and violent exercises; as the football, meeter for lameing, than making able, the users thereof, as likewise such tumbling trickes as only serve for comedians

and balladines to win their bread with ; but the exercises that I would have you to use, though moderately, not making a craft of them, are running, leaping, wrestling, fencing, dancing, and playing at the caitch, or tennise, archerie, palle-malle, and such like other fair and pleasant field games." The royal author proceeds to give his opinion at length on hunting and hawking, and on games in the house, which he thinks desirable, forbidding diceing, and somewhat strangely including chess among the prohibited pastimes. "As for the chesse, I think it over fond, because it is over-wise and philosophicke follie."

The banishment of football and of the rough and violent games proscribed by his Majesty may have saved some bruises and a broken leg or two, but it is hard to believe that the court of the Stuarts was much improved in manliness or vigour by their being discountenanced. Then came the troubles of the Great Rebellion. The Puritan spirit which **Puritans.** was dominant in the victorious party was not one which favoured any sports or games, and the times were against them. Notwithstanding, in country places they survived, and after the Restoration were again in favour. "Ringing, bowling, shooting, playing with keel pins, tronks, coits, pitching of bars, hurling, wrestling, leaping, running, fencing, mustering, swimming, playing with masters, foils, footballs, baloons, running at quintain, and the like, are common recreations of common folk," says Burton in his 'Anatomy of Melancholy,' and he goes on to mention of "riding of great horses, running at rings, tilts, tournaments, horse-races, and wild goose chases, which are disports of greater men and good in themselves, though many gentlemen by such means gallop quite out of their fortunes." There is, however, rather an air of apology in the way in which he speaks of the pastimes and recreations of the people, showing the strength of the Puritan feeling still prevailing, as when he says that, "Plays and jesters and jugglers and the like are to be winked at, lest the people should do worse than attend them." There is also reference to sports which in our eyes are less innocent, such as "bull-

baitings and bear-baitings, in which our countrymen and citizens greatly delight and frequently use," to which are added, "dancers on ropes, jugglers, comedies, tragedies, artillery gardens and cock-fighting!"

18th century. After the change of dynasty the character of the pastimes remained pretty much the same. According to Stowe's 'Survey of London,' published in 1720, "The modern sports of the citizens, besides drinking, are cock-fighting, bowling upon greens—they sometimes ride out with the Lord Mayor's pack of dogs, when the common hunt goes out. The lower classes divert themselves at football, wrestling, cudgels, nine-pins, shovelboard, cricket, stowball, ringing of bells, quoits, pitching the bar, bull and bear baitings, throwing at cocks, and what is worst of all, lying at alehouses." It is noticeable here that the division of pastimes is not into such as suit the old or the young, but rather as pursued by the upper and lower classes. With the exception of the "common hunt" the former do not seem to have indulged in any vigorous pastime. Football and cricket appear in the list of those games then in vogue among the lower classes, which are now popular with all. Later on in the same century, according to Maitland, in his history of London, published about the middle of George II.'s reign, "Sailing, rowing, swimming, and fishing in the river Thames, horse and foot races, leaping, archery, bowling in allies, and skittles, tennice, chess and draughts; and in the winter, skating, sliding, and shooting," are enumerated as the pastimes of the citizens, though it is obvious that they were not confined to the city of London alone, but were for the most part in general practice throughout the country. Legislation seems to have interfered occasionally to prevent gambling, but not altogether with much success. Towards the end of the last century the magistrates caused all the skittle frames in or about the city of London to be taken up, and prohibited bowling-alleys, and the games of nine-pins, Dutch pins, etc.; but, as Strutt remarks, when one pastime was prohibited another was presently invented to supply its place. Meantime the great games of the present

day (cricket and football), though played then in a very rough, and, as we should think, rustic fashion, were alive and gaining ground, and rowing was beginning to be thought of as an amusement in the summer months. Gradually a better tone prevailed, and the more brutal amusements, such as bear and bull-baiting, cock-fighting and the like, and last of all, though not without some delay, prize-fighting were put down by the law. Other amusements, and especially those in which a large number could join together for the purposes of play, became more and more popular in consequence, and cricket-matches and rowing-matches began to attract attention and to draw spectators. The Marylebone Cricket Club, founded in 1787, became by degrees the acknowledged authority in the game of cricket, which was rapidly assuming pre-eminence among the outdoor games of skill. A number of amateur rowing clubs also came into existence, and the inter-University match of the year 1829 gave to this pastime an importance which had not belonged to it previously. Henley Regatta was not founded till ten years after. Football became domiciled at the schools as the regular winter game, each having its own peculiar form of play; but it seems to have been little played by the general public. Tennis, restricted by its expensiveness to the wealthy and to professional players, still continued in the favoured places where courts existed, and fives and racquets found development at the public schools and at the universities. Athletic sports, as they are now called, had not as yet been co-ordinated, or taken the form of a regular series of contests on a given day between the two Universities; nor, unless we are mistaken, were there as yet any so-called athletic clubs. But pedestrianism was becoming popular. Walking and running matches found public support, professionals to train, and spectators enough to make it worth their while to do so. Prize-fighting still continued on the sly, though against the law; nor were there lacking some survivals of older games in the provinces, such as "nurr and spell," terms mysterious to the uninitiated. In the north also the noble

Cricket. **Rowing.** **Football.** **Tennis.** **Pedestrianism.**

game of golf—which is as old as the time of Edward III., if not of higher antiquity still, and seems then to have been called cambuc (from *cambuca*, a crooked club), and in England called also bandy-ball, or stow-ball—was, as it is now, a favourite pastime. Such we think may fairly be described as the state of athletic games and pastimes in England at the time of the Crimean War, thirty years ago. A number of *Bell's Life in London* of that date gives a fair idea of the popular sports and amusements of the time. The daily newspapers as a rule took no notice of them, except perhaps of horse-racing. The University Race was dismissed in the leading journal in those days with a few lines in small print in a corner. There was no popular excitement upon the subject, no crowd on the towing path at Putney to witness the daily practice of the crews. Similarly, at Lord's Cricket-ground there was no crowd to see the University or Public School matches comparable with the assemblage of modern days. Any one who takes up an ancient copy of the sporting newspaper referred to and compares it for bulk and variety of information with the *Field* or *Land and Water*, or even with itself of the present day, will feel that the difference is great. It is in reality very much greater than is suggested even by the comparison of the almost single journal of that date devoted to the subject with the multitudinous prints of the present day.

Thirty years ago.

5. Development of social athletics. Causes.

Athletics in this country have during the last quarter of a century advanced, as did the revenue in the palmy days of finance, by leaps and bounds. It is worth while, in the interest of the social "*mens sana*" and "*corpus sanum*," to consider both the facts in its proportions, and the causes that have contributed to it. There are several factors in the sum of athletic prosperity which may at once be recognised under the general head of increase. In the first place stands the enormous increase of town populations; next increase of wealth; then increase of the facilities of communication, and of the tendency to aggregation, owing to the spread of education, and of general enlightenment, and the wider recognition of the advantages

of co-operation for the purposes of amusement. To these we may add also the increase of physical vigour in the well-to-do classes, owing to better feeding, less physicking, and a more rational treatment of children. Lastly, we may notice, as connected with the development of athletics, the greater need of recreation owing to the increased and increasing pressure of mental work, of examinations, of competition in business, of the struggle for existence generally, which inevitably becomes severe even in prosperous times in an island the population of which has grown out of all proportion to its food-producing powers. A natural reaction from the pressure thus occasioned is satisfied in the most vigorous by exercise combining amusement and recreation, thus rehabilitating the exhausted energies of the brain and of the nerve, while preventing the degeneration of the muscular system which continuous sedentary employment induces. All these influences have tended during the last quarter of a century, and especially during the last decade, to give a stimulus to the development of athletics among the people, which is, we believe, unparalleled in the history of this or any other nation. Not indeed that this phenomenon has been confined to the English at home, for it is observable among the Anglo-Saxon races all over the world. The great American nation, Canada, and Australia, have become competitors with us in athletics as in other things, and are found yearly represented in friendly rivalry on the cricket-field and on the river. Even foreigners have to some extent been influenced by the athletic spirit which is alien to their youth and education, and of late years scullers from the Seine and from the Main have found their way to Henley-on-Thames.

Upper and middle classes.

The great increase of population in this country, nearly $3\frac{1}{2}$ millions in the decade 1871–1881, has been chiefly if not entirely urban, and not rural. And this fact is an important one to observe in respect of athletics, as their development is noticeable much more in the upper than in the lower strata of the town populations. To this fact and

its causes we shall revert in our last chapter, as we believe it is of great importance to our national well-being, to the national "*mens sana in corpore sano.*" With regard to the upper and middle classes the diffusion of wealth, and the general prosperity of the country in which they have largely shared, has been attended in their case not only with increased physical energy, but also with a rapid development of the means of supplying them with the physical recreation which they require. To omit for the present the public schools and the universities, where the organisation for games is, comparatively speaking, easy, and the difficulties that stand in the way of the satisfaction of the athletic instinct are of a different character, the extraordinary multiplication and growth of clubs and associations for every kind of exercise is a remarkable feature in modern English life. There is hardly a town of any size which has not got its football club, its cricket club, bicycle club, lawn-tennis club, or one or other of these. The instinct as well as the power of combination for the purposes of amusement has been quickened by increased facilities of communication and of locomotion, making the meetings for friendly contests possible, which would never have been thought of in former times. The matches, which now are innumerable, between club and club, town and town, county and county, all require organising and combined effort, and an expenditure which only the association of means in common funds could sustain. All this has been facilitated by the general progress of the nation, and is in its turn contributing to that progress in many ways; the healthy exercise giving common enjoyment, the social intercourse which enhances the value of self-control, and the respect for the opinion of others, as well as the desire for their good opinion, are largely efficacious in diffusing good-fellowship, dissipating prejudice, and creating bonds of union where the effect of party spirit, or of self-interest, would otherwise be unmitigated and disintegrating. Of course it is true that these influences of social athletics, if we may so speak of them, are not singular; they do not

Multiplication of clubs and matches.

stand alone. They are only part of the vast fabric of voluntary combinations for mutual benefit which the life of a free nation in a time of prosperity, if it is sound at the core, and not corrupted by immorality and irreligion, is sure to manifest. But still they are, as we have seen, peculiarly English, and they afford for the English physical life, with all its manly characteristics and joyous traditions, the outlet for its energies, especially in the time of youth, in a manner which operates largely towards the preservation of the "*mens sana*" in that important part of the nation, the rising generation. It is not likely that the stress, the wear and tear, and the pressure of work and anxieties that exhaust the sources of intellectual energy will become less severe in the future. On the contrary, we see that examinations are being multiplied daily, that the competition for them is growing in severity, and that apart from the handicrafts and commercial employments almost every means of gaining a livelihood is fenced with them at the outset. Education itself is rapidly becoming a question of how to get marks. The mind of the nation is so far cared for that provision has been amply made for its being exercised in its own gymnastics. There are some who do not think that enough has been done, and would increase the educational pressure upon the young still more. But it is not likely that we can go much further in this direction at present. There are already signs of reaction. What is really wanted is the reconsideration of our methods, and the alteration of them where they are faulty, while, at the same time, something should be done to ensure under the pressure of mental work that wholesome recreation of the brain by means of physical exercise and amusement which will give it the power to perform the tasks which modern life is now demanding of it. It is perhaps in the interests of the lower classes that this is most to be demanded at present. The upper and middle classes probably are able to take care of themselves in this respect, though it must be remembered that the true conditions of the problem are not at all touched by pointing out idle boys and idle young men of

Healthy aspects.

the well-to-do classes, and saying, "Here, see the result of your athletics. No danger of overstraining the mind here!" These are not the majority or anything but a small fraction of the whole number. The majority of the upper and middle classes, happily for them, have to work, must work, and do work, and it is for those who must work and do work that good and wholesome physical recreation is a necessity, if the "*mens sana*" is to be preserved in "*corpore sano.*" In their case however it may be conceded that there is no need to appeal to the legislature to help or encourage them. They have the means, and they have the energy and power to combine to provide themselves with the recreation that is suitable. The only thing for their sakes that is to be desired is that they should find wholesome and manly exercises to their taste, and not be allured or driven to those that are demoralising and destructive of health both in body and in mind. Perhaps the most unhealthy symptom in English sports and pastimes is the gambling and betting which accompanies most of them, introducing elements of suspicion and corruption which are the worst foes of the generous and chivalrous spirit which should be their presiding good genius. It may be said that this evil is inveterate in the race, and that it can be traced back even as far as the times of Tacitus. Still the progress of improvement and enlightenment which has done so much in other ways may, and we trust will, do something to mitigate and by degrees suppress it. All true lovers of athletics, all who desire through the vigorous and generous rivalry of physical exercises to assist social progress as well as to keep unimpaired the man by habits of the nation should join in discouraging and repressing by their own example and influence this habit which is antagonistic to their best desires. It is this element which has tended to lower professional athletics. If it is true that amateur athletics have been gaining and professional athletics have lost ground in public estimation, one of the reasons for this, and that not the least potent, is the mistrust that accompanies the latter owing to money being staked upon the

Unhealthy symptoms.

Gambling and betting.

Decline of professional athletics.

events in which they are concerned. We do not profess to regard this as a misfortune for athletics, for we do not think that athletics of any kind worthy of the name are absolutely in need of a professional standard to keep them up to the mark. Cricket certainly does not, nor rowing, nor football, nor bicycling nor lawn tennis, to name the physical exercises which now claim the greater number of votaries. We had far rather see all struggles for championship of every kind free from the hindrance of money stakes, and have the assurance that, whatever rewards might follow success, there should not be the inducement of gambling hazards tacked on to any athletic contest. The olive wreath of the Olympic games was the fitting type of a peaceful victory, nor did he who won it lack more substantial rewards at the hands of his admiring fellow-citizens. But here we touch on the question of athletics in relation to the classes which we are told have not any leisure to play games, and if they play them at all or contend in matches, must perforce do so as professionals in order to gain their daily bread. Otherwise they must stick to their trade. We are not sure that if the above contention were absolutely true the latter alternative would not be preferable. There are indeed kinds of professional aid in connection with athletics, which no doubt will always be in request. Professional keepers of the ground and bowlers at cricket, racquet and tennis markers and the like will always be necessary, and therefore to a certain extent professional athleticism will always continue, but we should none the less hail the day when a pastime was generally regarded as a pastime, and a game as a game, without the admixture of any money-getting motives. This will seem to many of our readers an Utopian view; and yet the expression of it does not in the least imply a desire to curtail the enjoyment of athletic pastimes among the wage-earning classes, the mass of the people. On the contrary, it is accompanied by the hope that they will in time obtain far greater facilities for wholesome recreation than they have at present. Should this ever come about, we may confidently expect to find in the far greater numbers that

Lower classes: desirable that social athletics should be developed among them.

will have the opportunities of distinguishing themselves in these pastimes many more individuals gifted with power and skill to excel in them than are ever heard of at present. We may expect to find in the representatives of clubs and counties, and of All England, a higher standard of excellence than is at present exhibited by either professional or amateur players. But as this is a question intimately connected with the education of the people, and one that can only be solved gradually, and will hardly be attempted by the present generation, we wish to reserve the consideration of it for a chapter by itself. We will only say here that there is no question in which the national "*mens sana in corpore sano*" is more deeply involved. Those who look below the surface, and are not merely occupied with the political and passing events of the day, know that the fostering of a manly and generous spirit among the toiling masses can best be assured by elevating the character of their pastimes, and infusing into them the desire for fair play and the unselfishness that distinguishes them at their best. Good old Strutt, at the beginning of his 'Sports and Pastimes of the English People' (to which valuable work we are indebted for the substance of the historical sketch of athletics in England which we have attempted to draw), sets forth, in words that are well worth consideration, the motive and object of his work. He says that in order to form a just estimation of the character of any particular people, it is absolutely necessary to investigate the sports and pastimes most generally prevalent among them. War policy, and other contingent circumstances, may effectually place men at different times in different points of view, but when we follow them into their retirements, where no disguise is necessary, we are most likely to see them in their true state, and may best judge of their natural dispositions. The picture that he proceeds to draw of our fathers and forefathers is not one of which we can altogether feel proud if we dwell at all on the cruelty and the gambling that disfigured too many of their pastimes. Public sentiment has pronounced so strongly against the former of these vices

that no such sports as bull-baiting and bear-baiting, which formerly were considered fit spectacles even for ladies to grace with their presence, would be tolerated. The law has also to a certain extent, while operating against gambling, put a check on certain other amusements once common. Meantime since the beginning of the century the population has nearly trebled. The sports and amusements which were formerly popular with the citizens of London, or any other of the great cities, are now available only to a fraction of them; and should the inquiry which Strutt proposed to himself ever be made in the case of the larger number, it is to be feared that it would be found that they have no sports or amusements that can properly be classed as athletics, and that the pastimes they do indulge in are not such as contribute to the creation of the "*mens sana in corpore sano.*" Whether anything can be done to remedy this defect or not is a difficult question, upon which we must not delay here. If anything can be done it will be necessary to begin with the young, who, as experience has shown, if without any traditions or habits of playing at games or of practising exercises, require to be taught and instructed in them before they will take to them or regard them at all in the light of amusement and recreation.

How, when once started and accepted by a community as part of their daily occupations, they may flourish and be the sources of health and enjoyment and social distinction, the history of athletics at our public schools and universities, and the experience of many who read these lines will amply testify.

CHAPTER V.

UNIVERSITIES AND PUBLIC SCHOOLS.

Development of athletics due to their example—Annual contests—Public schools—Generous traditions—Joy of games—Non-players—Fagging—Objects to be kept in view—House matches—Games that have died out—Games now in vogue adequate as physical exercise—University life—Pastimes—Many men take but little exercise—Reading men—Advice.

1. Development due to athletics at universities and public schools.

THE development of modern athletics, and their popularity with the general public, is due in a very large degree to the examples set by the Universities and Public Schools. The generous rivalry exhibited in matches and races between the representatives of these bodies has attracted general attention, not only because of the excellent play and excellent physique of those who take part in them, but also owing to the very conditions of the contest, in which the struggle is for the honour and glory of school or college or university, without any possible admixture of sordid or selfish motives to cast the shadow of suspicion upon the *bona fides* of the competitors. They are struggles in which the national soul has a joy and a pride, and that not unreasonably, if they have tended and do tend to elevate and purify the physical exercise and recreation of the national body. The influence that is thus exercised has increased enormously of late years. No one who is in the Metropolis during the week of the Universities Boat-race can fail to see the signs of the widespread interest taken in it, even by people who probably have never seen a boat in their lives. The colours in the shop-windows, and the bits of ribbon of light or dark blue tied on to the

cabmen's whips are outward and visible signs of a popular delight in the annual race, a delight which certainly has its value if it serves to encourage amateur rowing, and to make young and able-bodied men who want a vigorous and health-giving pastime turn their thoughts to Father Thames. The Universities cricket match at Lord's, and their athletic contests at Lillie Bridge, and the Eton and Harrow cricket match, have in their measure the same effect, popularising the pastimes of which they are annual, and as it were representative, exhibitions.

2. Public schools.

The public schools are the nurseries of the best of the national pastimes. Cricket and football, and, where there is a river, as at Eton, rowing, have their natural abodes amidst the vigour, the keenness, the energy, and the freshness of youth which is ever renewed. Here they have their best and most wholesome traditions fostering the spirit of generous and unselfish emulation, the spirit of fairness and honesty, the spirit of self-sacrifice and patriotism, which form and educate noble and manly characters capable of serving their country and of doing good to their fellow men. Here also they have their best time, if not their perfection, in a physical point of view. They assist growth, and develop the physical power while nature is building up the framework and nerves and muscles of the body towards its maturity. Here also they have their greatest delight and most memorable records in the individual life. What is there that can equal the joy of a good run down at football ending in a victorious goal, amidst the sympathetic applause of schoolfellows? Nothing can efface it. It is a bright spot in the old man's recollection of his boyhood. What can compare with the glory and present satisfaction of getting a wicket in the Lord's match, or that run by which the adversaries' score which promised them certain victory is placed in a minority of the one required? What can surpass in pleasure the sensation of easying under bridge after a hard race, while you watch the last two or three strokes of the House four or the pair or the sculler of whom you were so much afraid at the start?

Generous traditions.

Joy of games.

Non-players.

Most boys come to a public school from one or other of the innumerable private schools in the country. As we have already said, the individual brings with him a certain amount of formed habit, and proclivities which much influence the use that he makes of the time he has for play in the larger world to which he is thus introduced. It might be supposed by any one who did not know the truths of public school life that most boys were keen to play. But, strange to say, a very large number of boys, perhaps the majority, would, if left to themselves, never play at all at any game which required any personal exertion. As a matter of fact a large percentage do nothing but "loaf," as it is called, being unwilling to submit to the discipline and the fatigue of games in common. It is owing to this that cricket and football fagging are in force at some of the public schools, which ensure that the younger boys shall at least be present at the games so many times a week. This may in some cases be a hardship, and as a rule we prefer the doctrine of liberty, *i.e.*, that a boy's playtime should be as far as possible at his own disposal. Still there is no doubt that a great many boys who have afterwards become good players at cricket or football have, by their own avowal, been saved from becoming do-nothings and "muffs" by this compulsory discipline of school athletics. Each public school has its own rules as regards this practice, which, though diversely interpreted by the individuals who have had to submit to it, has in each case the sanction of tradition and authority on its side, and cannot lightly be interfered with.

Cricket fagging and compulsory football.

Chief object to cherish, manliness, generosity, unselfishness.

The great object of those who have to do with school athletics should be to foster that which is manly and generous and free in them, the love of fairness and the praise of patience, of courage, and of skill, and to repress vanity and vainglory, and, more than all, any brutality or meanness in them. The more that the individual sinks himself and his own excellence in the thought of the good of his house, or of his side, the better he is likely to play. Few things are more distressing to boys themselves or to

others than the morbid self-consciousness which is the parent of the worst nervousness, and which is ever thinking about what others will think or say of "ME." Of this self-consciousness the deliberate habit of caring for one's side, and of repressing the thought of self on principle is the best cure. House matches of all kinds are good as affording opportunities for the nurture of patriotic and unselfish feelings and preparation for the actors in them to play on a larger stage with self-possession and coolness. They also afford the means of selection for greater events, and they or their equivalents may be described as the backbone of school athletics.

Cure morbid selfishness.

House matches.

Cricket, and football, and lawn tennis, and bicycling will find a place in another handbook, and be sure of adequate treatment at the hands of the distinguished amateurs who have undertaken their history and description. Of rowing as a pastime we shall speak more at length in the next chapter.

Some games have died out.

It is a feature which is worth noticing that some games formerly popular at the schools have died out. There is no doubt a tendency on the part of those which employ most boys and create most rivalry, to oust the others, especially as each of these has its season during which alone it is predominant. Thus at Eton, and we believe at most public schools, football is king during the autumn; fives, beagles, and athletic sports divide the spring between them; and in the summer rowing and cricket are supreme.

Hockey.

Thus it has come to pass that hockey, which in the days of our fathers was so popular that it gave a name to some fields now forgotten, has entirely disappeared. An attempt to revive it a few years ago at Eton was a failure, and, except when there is skating, it is almost unknown to the boys of this generation. A similar fate has overtaken rounders and prisoners' base, once popular in some of the public schools. On the other hand, lawn tennis, popular as it is in the holidays, can only find a very limited and precarious footing during the schooltime, owing to the exigences and

Games now in vogue adequate as physical exercises.

perhaps the jealousy of cricket. Still, for all those who have any physical vigour, each season has in the dominant games ample amusement and physical exercise, and brings with it the rivalries which afford opportunities for distinction. Without any formal system of gymnastics, boys who play at these games find exercise in them for the whole muscular system. Arms, legs, muscles of back and chest and abdomen, all get their share of work and recreation in the natural movement of the young animal. Heart and lungs also have plenty of work to do, and in most cases are benefited by the tasks imposed upon them. For activity and grace of movement, for healthy mind in healthy body, there is nothing human that can compare with the best specimens of public school life as they pass the threshold from boyhood into manhood.

3. University life. Pastimes.

Such an one passing to the university finds himself strangely at a loss respecting his recreation. It no longer is a matter of course, nor does he find everything to his hand as he has been accustomed to find it at school. He has to take his own line. If he is a cricketer, and it is the summer term, he has not much difficulty in finding that pastime with his college club. If he is an oarsman, he will soon find his way to the Isis or the Cam, and be welcome in his college boat. But if he be neither of these, he will betake himself to racquets or tennis if he can afford it, or else he will take to riding or walking or bicycling as exercise. A football player has more chance now than formerly in the autumn term. But, with the exception of the cricket and the rowing, a man has to take some trouble for himself to get recreation, and everything is more formal and viewed in a somewhat more serious light than at school. Rowing, of all the pastimes in favour at the universities, affords the most regular and probably the best physical exercise, and certainly the most economical in money and time.

Many men take but little exercise.

A very large number of men, beyond a short walk, take no exercise at all worth the name, and are not as a rule the better for it. But by this time men are their own masters so far as the adoption of any line of

recreation is concerned, and each must choose for himself. Yet it cannot be too strongly impressed upon those who when still young feel the dislike of making any exertion, "too lazy to do this or to go there," that heart and lungs and brain as well as muscles of arms and legs have an interest, a life interest it might fitly be called, in their not yielding to ignavia. Similarly, to all reading men, and especially those who are working for an examination, we would say, "Your brain, in order that it may do its work, will require a continual supply, and that a large supply, of good arterial blood. What are you doing about your heart and lungs? They are deserving of all care on your part with a view to this examination which is your immediate object in view. They want exercise and fresh air to invigorate their movements and to oxidise the blood, without which your brain effort will be conducted under enfeebling conditions. And then, again, what are you doing as regards your brain? How many hours a day are you demanding work from it? It needs recreation and repose just as much as any tissue that is wasted by physical exertion. Take, then, out-door exercise, *as violent as you can physically afford*, regularly every day. Spend as much time as you can in the open air. Don't let your room get close and stuffy. Be careful as to diet. You ought to be in a kind of training, as you are in for severe physical competition, though you think it is only intellectual. Do, therefore, that which is fair by yourself in regard to physical exercise, and be quite assured, that your mental effort will be better and brighter, under good physical conditions, than if you ignore them and illtreat your brain by making it do work for you while your mode of life is absolutely enfeebling it."

Reading men. Advice as to healthy exercise.

Reading men who have narrow chests, and especially those who are short-sighted and inclined to stoop, should go to the gymnasium and perform, under the directions of the instructor, the light exercise which will tend to set them up and open the chest. They should, besides this, if they do not play at any games, never fail to ride if they

can afford it, or else take a brisk walk of not less than, say, four miles out and back every day. Or else they should go out by train, or drive out, some good distance, and walk back. And in their walk they should make it a rule not to talk about their work. Let the brain have a change to conversation about other things, to some out-door interest, to the botany, to the geology of the country they are traversing, at any rate to some variety which will give the fibres that have been kept at serious work that repose and recreation which is their due. Let them not forget that "*corpus sanum*" is quite as necessary to "*mens sana*," as "*mens sana*" is to "*corpus sanum*," if the whole man is to be at his best for the work to be done in life.

CHAPTER VI.

ROWING.

Numerous books but scanty records—Ancient—Mediæval—Modern—First regatta in England—Early clubs—Public schools and universities—University race—Sculling championship—Henley Regatta—Amateur clubs—Decline in professional rowing—Boats, changes in build — Outrigger — Keelless — Coxswainless fours — Sliding-seat — Instruction in rowing — Eton papers — Stroke — Sculling—Canoeing—Swimming.

As has been already stated, of the three most popular pastimes, cricket and football will be dealt with in another handbook. Rowing, therefore, alone remains to be treated of here. It is obvious that in a work of the present kind it would be impossible to do justice to a subject that would require for that purpose a treatise to itself. Already the art of rowing has a literature of its own, as the list given below will testify.* If we may be allowed to do so, we would here wish to express our obligations to the authors enumerated for information culled from their pages and made use of in these.

Rowing, numerous works on.

It is remarkable how scanty, until quite recent times, are the records of Rowing, an art which at certain epochs has played no insignificant part in the world's history. It was the oar that brought Phœnician letters and civilization to

But scanty records.

* Works on rowing : 'Principles of Rowing and Steering'; a well-known pamphlet, published at Oxford. 'Record of the University Boat Race,' Mr. Treherne. 'Eton Boating Book,' Mr. Blake-Humfrey. 'Boating at Oxford,' Mr. Knollys. 'Oxford and Cambridge Boat Races,' Mr. Macmichael. 'University Oars,' Dr. Morgan. 'Boat Racing,' Mr. Brickwood. 'Training in Theory and Practice,' Mr. McClaren. 'Rowing Almanack.' 'Account of the Regatta,' Kinch, Henley.

Greece. It was the oar that propelled the Hellenic fleet to Troy. It was the oar that saved Europe from Persian despotism. It was the skilful use of the oar by free citizens which was the glory of Athens in her prime. How is it that we know so little as to detail, that not even the acumen of a Boeckh, or the bold conceptions of a Graser, have been able to restore to us for certain, that "thing of life," the Attic trireme? We should like to know the disposition of the rowers on board that splendid fleet which started in its pride for Sicily, when 17,000 oars at a given signal smote the brine, and 100 long ships raced as far as Ægina. We should like to know about the sanitary arrangements, ventilation, etc., about the shape of the oars and the angle at which they touched the water. Or again, to pass to Roman times, we should like to have some satisfactory idea as to how the vast quinquiremes and hexiremes were propelled; some glimpse of the arrangement on board their vessels of that mass of human beings who rowed and perished in the greatest sea-fight of all time, in the battle of Ecnomus.

Ancient. Boat-racing was not uncommon among the Greeks, as Professor Gardner has shown in an excellent paper on the subject.* Any one who would wish to find a pretty name for his boat will do well to look at the list of Greek names of vessels he has given. That boat-racing was also common among the Romans, what admirer of Virgil will fail to believe? But among the Romans, as among the Greeks, the art of rowing deteriorated as it became, not a joyous pastime for freemen, but the cruel toil of slaves.

Mediæval. In mediæval times the Venetian galleys used the same means of propulsion. But the art of building vessels for three or more banks of oars had been lost, and neither the paintings in the ducal palace at Venice, representing the fleet that fought at the battle of Lepanto, nor the patriotic enthusiasm of Admiral Fincati, nor the learned tomes of M. Jal can induce us to believe that we see in the long, low, red craft of Venice anything resembling, in

* 'Journal of Hellenic Studies,' 1881.

external shape or internal arrangement, the trireme of the days of Phormio or Iphicrates.

Italy, however, was the home of rowing at a time when we have no record of it here; and the very word "regatta" which we have adopted shows that we owe something as regards the pastime to the countrymen of Columbus and Marino Faliero.

With the exception of the well-known story that graces most of the children's English History books, concerning Edgar the Peaceable, who was rowed in great state along the river Dee from his palace in the city of West Chester to the church of St. John and back again, by eight kings, himself, the ninth, acting as coxswain, little or nothing is heard of rowing in England till the year 1453, when John Norman, the then Lord Mayor, set the example of going by water to Westminster. This we are told made him popular with the watermen of the day, as his example was followed, and the use of pleasure boats by the citizens became common.

Modern.

Next in importance to this event comes the foundation, in 1715, in honour of the accession of the House of Hanover, by Doggett the comedian, of a race for a coat and badge to be rowed for by watermen apprentices from Old Swan Stairs, near London Bridge, to the White Swan at Chelsea, annually, on the 1st of August. This race still continues, though not exactly on the old terms. The coat and the badge with the white horse of Hanover preserve the memory of the donor, and of the event in honour of which the race was instituted.

First regatta in England.

Mr. Brickwood in his well-known work tells us in a note that "the first regatta on the Thames was held in front of Ranelagh Gardens on June 23rd, 1775." He does not give the authority. But we find in Strutt the following: "Of late years, the proprietor of Vauxhall Gardens, and Astley the rider, give each of them, in the course of the summer, a new wherry to be rowed for by a certain number of watermen, two of which (*sic*) are allowed to row in one boat, and these contests are extended to two or three heats or trials before

the successful candidates are determined." Strutt's book was first published in 1801, so that we have here a note of pair-oared races before the end of the last century. As Ranelagh Gardens was a rival institution to Vauxhall, and Astley, the rider, also a caterer for public entertainment, it seems probable that the first regatta of Ranelagh, in 1775, having made a successful *début*, caused a repetition and popularised the amusement.

Early amateur clubs.

It is clear that at the beginning of the present century there were a number of metropolitan amateur clubs in existence. The river, before old London Bridge was pulled down, and before steamboats ploughed its surface, must have been far more suitable for row-boats than it is now. But the doings of the clubs and the very names of all but a few have perished, "lost in long night, unwept, unknown, for want of bard divine." Mr. Brickwood cites the names of the "Star," the "Arrow," and the "Shark" clubs; to which we can add from the oral testimony of an ancient mariner, the "Siren," some members of which, about the year 1814, rowed a race from Putney Bridge to Kew Bridge, went on to Richmond and dined, and thence drove back to town.

Our informant added that matches from Westminster to Kew and Putney to Kew were not unusual at the time. The length of the race seems to us excessive. But the boats were large and held their way well, the oar-blades narrow, and the rate of stroke slow, and fouling not only allowed but practised as a matter of course. They generally rowed in white duck trousers and white or striped shirts or guernseys.

Rowing at public schools and universities.

Of the public schools and universities, Eton seems to have been the first to gain fame in aquatics. It possessed a fleet of long boats certainly in 1811, if not before. In that year it had one ten-oar, three eight-oars, and two-six oars. The record of Westminster begins in 1813, and we hear of a challenge from Eton in 1808. But the school authorities of those days do not seem to have viewed the pastime with friendly eyes, and on this and on other

occasions took active measures (even to locking up half one crew) to prevent the race being rowed.

Rowing had already found favour at Oxford as an amusement. The first record of college eights racing is in 1815. At Cambridge, owing no doubt to the less inviting character of the river, eights do not seem to have been in fashion before 1827.

University race. The first University race was rowed at Henley in 1829, and the first Eton and Westminster match in the same year. These matches were not annual, as will be seen by the lists annexed. The Universities match has been annual since 1856. The Eton and Westminster match dropped for thirteen years after 1847 and was renewed in 1860, but since 1864 has been in abeyance.

UNIVERSITY RACES.*

Year.	Date.	Winner.	Course.	Time. m. s.	Won by
1829	June 10	Oxford .	Henley . . .	14 30	easily.
1836	June 17	Cambridge	West. to Putney	36 0	1 min.
1839	April 3 .	Cambridge	West. to Putney	31 0	1 min. 45 sec.
1840	April 15	Cambridge	West. to Putney	29 30	¾ length.
1841	April 14	Cambridge	West. to Putney	23 30	1 min. 4 sec.
1842	June 11	Oxford .	West. to Putney	30 45	13 sec.
1845	March 15	Cambridge	Putney to Mort.	23 30	36 sec.
1846	April 3 .	Cambridge	Mortlake to Put.	21 5[1]	2 lengths.
1849	March 29	Cambridge	Putney to Mort.	22 0	easily.
1849	Dec. 15 .	Oxford .	Putney to Mort.	— —	foul.
1852	April 3 .	Oxford .	Putney to Mort.	21 36	27 sec.
1854	April 8 .	Oxford .	Putney to Mort.	25 29	11 strokes.
1856	March 15	Cambridge	Mortlake to Put.	25 50	½ length.
1857	April 4 .	Oxford .	Putney to Mort.	22 35[2]	35 sec.
1858	March 27	Cambridge	Putney to Mort.	21 23	22 sec.
1859	April 15	Oxford .	Putney to Mort.	24 40	Camb. sank.
1860	March 31	Cambridge	Putney to Mort.	26 5	1 length.
1861	March 23	Oxford .	Putney to Mort.	23 30	48 sec.
1862	April 12	Oxford .	Putney to Mort.	24 41	30 sec.
1863	March 29	Oxford .	Mortlake to Put.	23 9[3]	43 sec.
1864	March 19	Oxford .	Putney to Mort.	21 40	26 sec.
1865	April 8 .	Oxford .	Putney to Mort.	21 24	4 lengths.
1866	March 24	Oxford .	Putney to Mort.	25 35	15 sec.
1867	April 13	Oxford .	Putney to Mort.	22 40	½ length.
1868	April 4 .	Oxford .	Putney to Mort.	20 56	6 lengths.
1869	March 17	Oxford .	Putney to Mort.	20 5	3 lengths.
1870	April 6 .	Cambridge	Putney to Mort.	22 4	1½ lengths.
1871	April 1 .	Cambridge	Putney to Mort.	23 5	1 length.

[1] The first University race rowed in outriggers.
[2] The first race in which either University rowed in the present style of eights without keels; also the first time either rowed with round oars. Both used the same kind of oars and boats.
[3] From the High bridge to Putney Pier.

* From the 'Rowing Almanack.'

UNIVERSITY RACES—*continued.*

Year.	Date.	Winner.	Course.	Time. m. s.	Won by
1872	March 23	Cambridge	Putney to Mort.	21 15	2 lengths.
1873	March 29	Cambridge	Putney to Mort.	19 35[1]	3¾ lengths.
1874	March 28	Cambridge	Putney to Mort.	22 35	3 lengths.
1875	March 20	Oxford .	Putney to Mort.	22 2[2]	10 lengths.
1876	April 8 .	Cambridge	Putney to Mort.	20 20	8 lengths.
1877	March 24	Oxford . / Cambridge	Putney to Mort.	24 8[3]	dead heat.
1878	April 13	Oxford .	Putney to Mort.	22 13	10 lengths.
1879	April 5 .	Cambridge	Putney to Mort.	21 18	4 lengths.
1880	March 22	Oxford .	Putney to Mort.	21 23	4 lengths.
1881	April 8 .	Oxford .	Putney to Mort.	21 51	3 lengths.
1882	April 1 .	Oxford .	Putney to Mort.	20 12	8 lengths.
1883	March 15	Oxford .	Putney to Mort.	21 18	3½ lengths.
1884	April 7 .	Cambridge	Putney to Mort.	21 39	2½ lengths.

N.B.—In addition to the above, the Universities have contended together five times at Henley Regatta, in the same heat for the Grand Challenge Cup, and the following table shows the winners on those occasions:

Year.	Date.	Winner.	Time.	Won by
1845	June 7	Cambridge	8m. 30s.	2 lengths.
1847	June 17	Oxford	8 4	2 lengths.
1851	June 17	Oxford[4]	7 45	6 lengths.
1853	June 11	Oxford	8 3	1½ feet.
1855	June 25	Cambridge	8 32	8½ lengths.

Also at the National Thames Regatta on June 22, 1824, Oxford beat Cambridge.

From the above record it will be seen that Oxford are now four matches ahead, forty-one having been rowed.

ETON AND WESTMINSTER RACES.

Year.	From	To	Winner.	Remarks.
1829	Putney	Hammersmith and back	Eton	by ¾ of a mile.
1831	Maidenhead Bridge	Queen's Eyot and back	Eton	by ¼ of a mile, 45 min.
1836	Staines Bridge	Penton Hook and back	Eton	several boat's lengths.
1837	Datchet Bridge	New Lock and back	Westminster	no time given. King William IV. present.
1842	Kew Eyot	Putney	Westminster	by 35 secs., in 34 mins.
1843	Putney	Mortlake	Eton	in 24 mins., by 45 secs
1845	Kew Eyot	Putney	Westminster	in 26 m., by 1 m. 5 s.
1846	Putney	Mortlake	Westminster	3 lengths.
1847	Barker's Rail	Putney	Eton	in 25 mins. 50 secs. by 1 min. 30 secs.
1860	Putney	Chiswick Eyot	Eton	by 50 secs.
1861	Putney Bridge	Chiswick Eyot	Eton	by 7 or 8 lengths.
1862	Putney Bridge	Chiswick Eyot	Eton	in 13 mins. 5 secs.
1864	200 yds. above Chiswick Eyot	Star and Garter	Eton	by 27 secs.

[1] Only four steamers allowed since this year.
[2] Both crews used sliding seats for the first time.
[3] Oxford sprung an oar.
[4] Cambridge lost a rowlock soon after starting.

The sculling match for the championship was first rowed in 1831, when it was won by C. Campbell of Westminster, who retained it for fifteen years, when it was wrested from him by R. Coombes of Vauxhall, a small man not scaling 9 stone, but of surprising power for his size, who held it till 1852. Of late years the Colonies have laid claim to it with success, and it has been in the keeping of Hanlan, of Toronto (who is deservedly considered the finest sculler in the world), ever since 1879. Sculling championship.

Henley Regatta was founded in 1839, and has ever since been regarded as the principal aquatic event of the year, after the race between the two Universities at Easter. Henley Regatta.

Here about the beginning of July is held the great amateur gathering, which seems year by year to gain in popularity. Here every class of rowing may be observed, eights, fours, pairs, and scullers. College eights from the universities, from the great metropolitan clubs, and from the schools, and scullers from all parts come to contend, and lend animation to river and river-bank with flashing oars and coats of many colours. As a spectacle, few things are more enchanting than Henley in fine weather at the time of the Regatta. Of late years the crowd of spectators on the water has been excessive, so that the course has been encroached upon to an extent operating very unfairly upon crews starting on the Bucks side. This and the question of the corner which gives an advantage to crews on the Berks side on most days are two subjects which agitate the rowing mind at the present day whenever thoughts are turned to the coming Regatta.

The Leander Club, founded probably about 1820, is the oldest of the existing metropolitan clubs. The London Rowing Club was founded in 1856, and such has been during the last thirty years the increasing popularity of rowing as a pastime, that the metropolitan and suburban clubs alone number over forty at the present time. Amateur clubs.

Next to Henley the most important regatta is the Metropolitan Amateur Regatta established in 1866. The Thames National Regatta for Watermen came to a con- Decline of professional rowing.

clusion in that same year, and though a Thames Regatta was established in 1868 to supply its place, it cannot be said to have flourished, even if it still survives. Not even the prizes given by the great liberality of Messrs. Chinnery for scullers have been able to resuscitate professional skill and power, which used to be able in sculling and rowing to hold its own against the world. Steam has to a certain extent contributed to this result, as the waterside population no longer can make a livelihood by conveyance of passengers in rowing boats. Hence there are fewer professional watermen than in former times. But this will hardly account entirely for the decline of professional rowing, which is as conspicuous as is the increasing popularity of the pastime with amateurs.

Changes in build, etc., of boats.

It would be superfluous here to follow the history of aquatic events any further, as information regarding them is so easily accessible in the books already quoted. But there have been certain changes in the build of boats, and in the fittings of them, as well as in the shape of oars, which are noticeable as affecting the speed, and in some degrees the method, of propulsion. These are deserving of attention.

Early boats.

The boats of the earlier time were large and roomy craft, and would be considered barge-like by the amateur of the present day. Some had a gangboard down the centre. It was no uncommon thing for the captain to shove off from shore or out of locks (races actually went through the locks, the boats waiting for each other if in sight), and then to run down the middle of the boat and take his place at the stroke oar. The boats were therefore very much broader in beam and shorter in length than modern craft.

The upper streak was in one line, with the rowlocks let into it gig-fashion. The first change was the cutting-down of the upper and second streaks between the rowlocks, with a view to reducing the weight. Then followed the invention of the outrigger by Clasper about the year 1842, first adopted in the University race of 1846. This invention

Invention of outrigger.

enabled the beam to be contracted, while the length of the oar in-board remained the same. Gradually the outriggers were lengthened (having at first been only about eight inches long) and the beam contracted, until a racing eight took the form of a narrow ship 57 to 60 feet long and about two feet wide at the broadest part. These were all "clinker-built," that is in "streaks" overlapping each other, a mode of build still usual in what are called gig-boats. Efforts were being made by boat-builders to adapt the "Carvel build," so as to give a perfectly smooth exterior to the water, and by the year 1855 many college eights at Oxford were of this build, which was becoming common. All these boats had a keel. But in the next year, 1856, a keelless boat, built with a thin cedar skin fitted on to strong ribs, by Matthew Taylor, for the Royal Chester Rowing Club, carried everything before it at Henley Regatta, and became the pattern of construction for racing boats of the present day. Keelless boats were used by both the Universities in the 1857 race at Putney. **Keelless boat.**

Oars. The oars of the olden time were square in the loom, with a square button to prevent them slipping out of the rowlock. The blades were long and much narrrower than those of the present day, and the stroke was rowed at a greater angle to the water. Gradually, as the boats have decreased in size and the oarsman has been brought down nearer to the level of the water, the blades have been made shorter and broader. The usual type of blade now is about three feet in length, and six inches, or even more, at the extreme end, which is the widest part. An improvement remains to be adopted by which the whole blade will be immersed at once, thus taking the whole of its propelling area into play without any "slip," as is at present the case. The normal length of oars is from three feet six inches to three feet nine inches in-board, eight feet seven inches to nine feet out-board, the balance of the oar out-board depending on these proportions. Sculls for racing purposes are generally about ten feet long with five-inch blades, and are used overhanded, that is to say, with the

handles overlapping when the sculls are perpendicular to the sides of the boat.

Coxswainless fours.

Of late years four-oars, which till the year 1873 used to carry a coxswain at the regattas, have been rowed without coxswains; the steering being effected by an ingenious apparatus whereby one of the crew turns the rudder either to the right or left by the pressure or inclination of either foot. It cannot be said that the steering of four oars has been improved by the transfer of the yoke-lines from the hands to the feet, nor is it likely to be satisfactory until by some process of evolution the "jolly young waterman" of the future is provided with eyes in the back of his head. But some improvement no doubt will be made in the steering gear, the adaptation of electricity to which is a problem not unlikely to be solved by some scientific and practical oarsman at no distant date.

Sliding-seat.

But of all the improvements in the boats of modern days the most remarkable is that of the sliding-seat, an American invention first publicly used in 1870. This enables the rower to shift his position during the stroke from a point as near to the thwart, against which he works, as the bending of his knees upwards, while his feet are firm against the stretcher, will allow, to a point as far off from that work as the straightening of his legs and flattening of his knees will carry him. This, in the case of a man of six feet in height, is as nearly as possible *fifteen* inches, horizontally measured. This is the extreme; but as there is in the extreme forward position a loss of power to the body in the boat, owing to the cramping of the muscles, and in the extreme backward position a loss of power in the action of the oar in the water, and a difficulty in recovery created, these extremes are as a rule avoided, and a margin allowed at either end, reducing the actual length of slide to from twelve to nine or even six inches, according to the judgment of the individual or the trainer of the crews.

In the old type of boats, when the oarsman was seated high above the water, he could at the beginning of the

stroke actually lift himself off his seat, and let the whole weight of his body tell on the handle of the oar and the stretcher simultaneously. As the angle at which the oar touched the water, owing to the improvements in boat-building, became more acute, the weight of the man was brought more and more on to the seat and less and less on to the stretcher. Hence, when in accordance with the true principles of the stroke a man sought to apply his weight as well as his strength to the handle of the oar, it was still an attempt to suspend himself between the handle of the oar and the stretcher, leaving as little of his weight on the seat as possible. But it is obvious that, owing to his position at a fixed distance, twelve or thirteen inches from his work, this suspension of the body could only operate during the first few inches of the stroke; that is, when his body was well forward. As soon as the body neared the perpendicular line the weight resided on to the seat, and the remainder of the stroke was accomplished by muscular contraction alone. Already towards the end of the days of fixed seats there was a tendency to set the work nearer to the seat, and some of the fastest crews at Henley were rowing with work at 11½″, 11″, or even 10½″. If a very fast stroke is rowed, it will naturally be shorter in the water than a slow one; and as the first half of the stroke is the most important part of it, that distance was sought out which, owing to the position of his body in relation to the handle of the oar and the stretcher, would enable the man to employ his weight at the beginning to the best advantage. Already the prolongation of this advantageous position by sliding back on a fixed seat lubricated for the purpose had been practised by some scullers and some oarsmen, but for obvious reasons it was only partially successful. Sill it was a move in every sense in the right direction for the continuation of the muscular effort, by which weight and strength could be applied to the water, and the muscular effort of the legs maintained for a longer time. Thus much may be said as to the physical aspect of the question up to this point; but there

is also the mechanical, which was engaging the attention of clever oarsmen on the other side of the Atlantic.

Advantage of sliding over fixed seat.

Mechanically speaking, in rowing, the water is the fulcrum, the boat is the weight to be moved, the oar is the lever, and the man applies the power. The leverage is most powerful when applied at right angles to the weight; but in the problem to be solved, owing to the motion of the oar itself through the water, and the motion of the boat through the water, the moment at which this can be the case is extremely transient. Could any satisfactory mechanism be devised by which the weight—that is the thowl against which he rows—could be moved forward during the stroke, while the oarsman was still in the position to exert his full power against it, we might expect a great increase of speed. This however is a structural problem not yet solved. But the sliding seat in some measure answers the purpose by enabling the oarsman or sculler to continue his physical effort by the straightening of his legs in such a way that his power and his weight, which is, as we have shown, most available at the beginning of the stroke, is operative in the water for a longer period during each stroke than it could be if he was on a fixed seat. The gain is much less than that of a moving rowlock would be, because, owing to the rising of the knees when the slider is forward a man cannot obtain a much greater reach forward than he could on a fixed seat. It is when the body has moved up towards the perpendicular, and the water has already been got hold of, that the advantage of the sliding seat begins. As the slider moves back, the uncoiling of the human spring, which is bedded in the stretcher, can go on with undiminished force for the distance of the slide, when the pressure of the legs ceases and the weight of the body is again entirely thrown on the seat. The mechanical advantage is here mostly after the rowlock, and that, as we have already stated, is the least valuable part of the stroke, especially in a light boat. Still the gain is considerable, as it enables more weight and more strength to be applied to the oar for a longer portion of the stroke.

Further, there has been for grown men a physical gain in that the increased length of stroke enables the same pace to be attained with fewer strokes per minute. The pace of inferior or mediocre crews accordingly has been improved. Moreover, the effort of swinging the body forward to its fullest reach, which on the fixed seat was necessary, is now greatly reduced by the mechanism of the slide, and consequently the exertion to heart and lungs is much less. This is a gain to those who, by reason of age and figure, are not so lithe and active as in boyhood ; but it has been a loss to public school crews, who could make up formerly by pace of stroke and agility for their inferiority in strength to men. The record of the Ladies' Challenge Plate at Henley bears witness to this.

Increase of pace not so great as might be expected.

As regards increase of pace it is not so great in the case of eight oars as might have been imagined and is often stated.

The average pace of the last ten years, according to the 'Rowing Almanack,' of fixed seats (1863–1872) and of sliding seats (1874–1883) was as follows :

	Fixed. min. sec.	Sliding. min. sec.
Grand Challenge Cup. . . .	7·48	7·45
Ladies' Plate	7·53	8·5
University Boat Race. . . .	22·11	21·44

The last ten years however at Henley have not been favourable to speed, or no doubt the slider would have shown to greater advantage. As it is, the chief eight-oar races at Henley when taken together show at present on the ten years an average of 9 seconds in favour of the fixed seat. The University race, on the other hand, of 4¼ miles on the tideway gives an advantage to the slider of 27 seconds.

The best pace of the fixed seat and of the slider compared on the Henley course is given in the 'Rowing Almanack' as follows :

	Fixed. min. sec.	Slider. min. sec.	sec.
Eight-oars	7·18	7·3 —	15
Four-oars.	8·5	7·56 —	9
Pairs	9·0	8·45 —	15
Sculls	9·6	9·10 —	4
University Race	20·5	19·35 —	40

But these instances, though interesting, are not really to be relied on as determining the question of relative advantage, for the circumstances under which the races in question were rowed were different, and stream and wind are far more potent in helping or retarding the pace of a boat than any adjustment of fixed seats or sliders can be.

Instruction in rowing.
1 Individual.
2. Collective.

To row in one of the great races of the year is a legitimate aspiration for any amateur, but before he can reach that excellence which would fit him for such an honour, he must have learnt the art of rowing from the beginning. He must have learnt it individually, so as to be able to apply his own body and limbs correctly to the actual work of propulsion. He must have learnt it socially, so to speak, as a part of a crew, so as to be able to keep time and rhythm and exactness in the application of his power at the right moment with the stroke. Those who teach rowing have to teach it individually and collectively, which are two very different things. It would exceed the limits of the present handbook to attempt to enter into the details of instruction for either individual or crew. We subjoin, however, copies of the two summaries which have formed the basis of the teaching of the Eton crews who have rowed for the Ladies' Challenge Plate at Henley during the last twenty years.

Eton papers.

NOTES ON THE STROKE.

ΧΑ. σὺ μὴ φλυαρήσεις ἔχων ἀλλ' ἀντιβὰς
ἐλᾷς προθύμως;
ΔΙ. κᾆτα πῶς δυνήσομαι,
ἄπειρος ἀθαλάττωτος ἀσαλαμίνιος
ὢν εἶτ' ἐλαύνειν;
ΧΑ. ῥᾷστ'· ἀκούσει γὰρ μέλη
κάλλιστ', ἐπειδὰν ἐμβάλῃς ἅπαξ.—*Ar. Ran.* 202.

The moment the oar touches the body, drop the hands smartly straight down, then turn the wrists sharply and at once shoot out the hands in a straight line to the front, inclining the body forward from the thigh-joints, and

simultaneously bring up the slider, regulating the time by the swing forward of the body according to the stroke. Let the chest and stomach come well forward, the shoulders be kept back ; the inside arm be straightened, the inside wrist a little raised, the oar grasped in the hands, but not pressed upon more than is necessary to maintain the blade in its proper straight line as it goes back ; the head kept up, the eyes fixed on the outside shoulder of the man before you. As the body and arms come forward to their full extent, the wrists having been quickly turned, the hands must be raised sharply, and the blade of the oar brought to its full depth at once. At that moment, without the loss of a thousandth part of a second, the whole weight of the body must be thrown on to the oar and the stretcher, by the body springing back, so that the oar may catch hold of the water sharply, and be driven through it by a force unwavering and uniform. As soon as the oar has got hold of the water, and the beginning of the stroke has been effected as described, flatten the knees, and so, using the muscles of the legs, keep up the pressure of the beginning uniform through the backward motion of the body. Let the arms be rigid at the beginning of the stroke. When the body reaches the perpendicular, let the elbows be bent and dropped close past the sides to the rear—the shoulders dropping and disclosing the chest to the front ; the back, if anything, curved inwards rather than outwards, but not strained in any way. The body, in fact, should assume a natural upright sitting posture, with the shoulders well thrown back. In this position the oar should come to it and the feather commence.

N.B.—It is important to remember that the body should never stop still. In its motion backwards and forwards it should imitate the pendulum of a clock. When it has ceased to go forward it has begun to go back.

There are it will appear, from consideration of the above directions, about 27 distinct points, *articuli* as it were, of the stroke. No one should attempt to coach a crew

without striving to obtain a practical insight into their nature and order of succession.

Let a coxswain also remember that, in teaching men to row, his object should be to teach them to economise their *strength* by using properly their *weight*. Their weight is always in the boat along with them; their strength, if misapplied, very soon evaporates. E. W.

ETON, *Feb.* 12, 1875.

NOTES ON COACHING.

Ἐπισταμένοις δ' ὑμῖν γράφω ὅτι ὀλίγοι τῶν ναυτῶν οἱ ἐξορμῶντές τε ναῦν καὶ ξυνέχοντες τὴν εἰρεσίαν.—THUCYD. VII.

In teaching a crew you have to deal with—

A. Crew collectively;
B. Crew individually.

A. COLLECTIVE—

1. Time—*a.* Oars in and out together.
   β. Feather, same height—keep it down.
   γ. Stroke, same depth—cover the blades, but not above the blue.
2. Swing—*a.* Bodies forward and back together.
   β. Sliders together.
   γ. Eyes in the boat.
3. Work—*a.* Beginning—together, sharp—hard.
   β. Turns of the wrist—on and off of the feather, sharp, but not too soon.
   γ. Rise of the hands—sharp, just before stroke begins.
   δ. Drop of the hands—sharp, just after it ends.

General Exhortations—"Time!" "Beginning!" "Smite!" "Keep it long!" and the like—to be given at the right moment, not used as mere parrot cries.

B. INDIVIDUAL—1. Faults of Position.
2. Faults of Movement.

N.B.—These concern Body—Hands—Arms—Legs, and sometimes Head and Neck.

1. Point out when you easy, or when you come in, or best of all, in a gig. *Show* as well as *say* what is wrong and what is right.

N.B.—Mind you *are* right. "*Decipit exemplar vitiis imitabile.*"

2. To be pointed out during the row and corrected. Apply the principles taught in "E. W.'s" paper on the stroke, beginning with bow and working to stroke, interspersing exhortations (A) at the proper time.

N.B.—Never *hammer* at any one individual. If one or two admonitions don't bring him right, wait a bit, and then try him again.

For coaching purposes, not too fast a stroke and not too slow. About 30 per minute is right.

Before you start, see that your men have got their stretchers right and are sitting straight to their work.

HE TEACHES BEST WHO, WHILE HE IS TEACHING, REMEMBERS THAT HE TOO HAS MUCH TO LEARN.

E. W.

ETON, *March 1st*, 1875.

Those who desire to learn more from books upon the subject, should consult the 'Principles of Rowing and Steering,' and Mr. Brickwood's treatise on 'Boat-Racing.' Addenda.

It is all-important to begin to learn to row on a fixed seat, and to understand the correct position for hands, legs and body when first taking a seat in a boat, and the reason for each. These concern the health as much as the successful manipulation of the oar. The positions should all be natural and unconstrained. All tricks, such as side jerking of the knees, turning of the head on one side,

looking at the oar during the stroke, arching outwards of the back, turning out of the elbows, etc., should be avoided by the learner and corrected by the teacher.

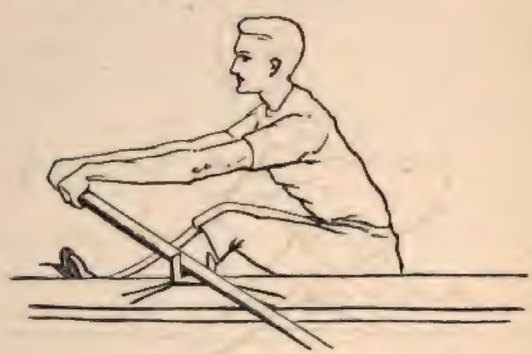

FIG. 1.—ROWING. FIXED SEAT—FORWARD.

Considering the strain which is put on the muscles during the stroke, it is most important that at the end of the stroke and during the recovery no more muscular

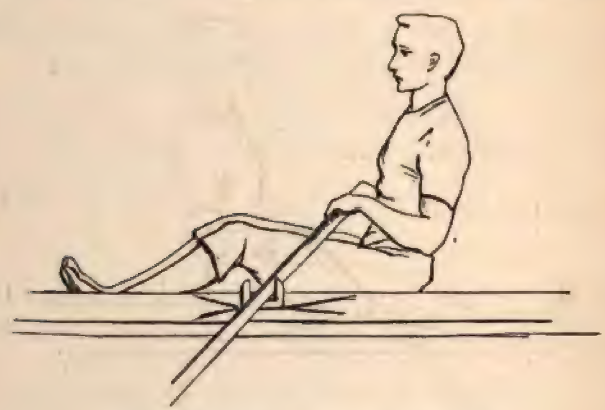

FIG. 2.—ROWING. FIXED SEAT—BACK.

power should be exerted than is necessary for the bringing forward the body and the oar into the position for the next beginning. During this time of muscular relaxation the chest should be expanded, the shoulders kept from con-

verging inwards, the arms shot out in a straight line from the body, with hands rising towards the level of the shoulder. Thus a good inspiration can be taken, filling

FIG. 3.—ROWING. SLIDER—FORWARD.

the lungs and supplying its full share of oxidised blood to the heart, which will also be left free for its expansion and

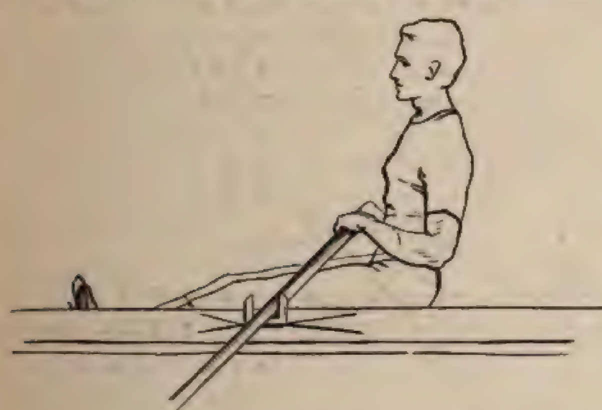

FIG. 4.—ROWING. SLIDER—BACK.

contraction, quickened by the exercise of rowing, if the chest is uncontracted and the back straight.

It cannot be too strongly insisted on with beginners that not only the muscles of arms and legs have to be got into

rowing condition in order to do the work satisfactorily, but that heart and lungs also have to be habituated to do their share, which is no small part of the work.

In teaching a beginner, nothing is more prejudicial than to keep him going too long at a time. Frequent "easies," and explanations, and practical examples, the coach showing him, by taking the oar himself, what he has done wrong and how to do right, help and encourage him better than any long labour will do. As he becomes more handy the effort can be prolonged with advantage, and faults talked about afterwards. There are two very common faults in coaching, especially where, as is often the case at public schools and the universities, those who undertake to teach have themselves very imperfect knowledge of the art. They say too much, they think too little about the causes of faults, and are content with telling the individual to correct them without letting him know how to do it. It is most important to get men or boys to use their brains in rowing as well as their arms and legs. We remember a saying, that was in old days handed down in our College Boat Club, and attributed to a famous and most conscientious oarsman (who has now taken his seat on the judicial bench): "I never row a stroke without thinking if there is anything wrong with it." This should be the habit of mind in the oarsman who wishes to excel. But it is not easily created by the bewildering discipline to which many beginners are subject. We remember seeing on the Isis some years ago, one fine afternoon in the beginning of the summer term, a luckless four being coached, presumably with a view to the summer races. They had great wealth of instructors. Two they carried in the boat, a roomy gig, with them beside the coxswain, and two were running on the bank. All were shouting at them at intervals. It would be very difficult to learn or to maintain a conscientious resolve to correct one's faults under the circumstances. It is an axiom that one, and one only, should teach at a time, and that the crew should understand who it is to whom they are to listen.

A stroke, as has often been said, like a poet, "nascitur, non fit," but any one who is placed in that position should remember in the first place that the crew has to row to him and not he to the crew. He should be careful to maintain the same number of strokes per minute, unless he deliberately desires to quicken or to slow down. He should be master of the time. He should also set the work. Many a crew is apparently rowing in time, that is to say, with oars entering and leaving the water at the same time, but in reality is not doing the work simultaneously. It is the stroke's chief function to secure that identity of catch at the beginning, on the part of the whole crew, which, if they are powerful and row it through, means pace, and probably victory. There have been light strokes behind whom powerful crews have done great things, but as a rule it is well that a stroke in reach and power should not be below the average of his crew. The stroke.

To the sculler the rules given above will equally apply, allowance being made for his work being divided between his two hands. As the sculls overlap he will have to move one hand above the other as they pass in the middle of the stroke and the recovery. It does not matter which is uppermost, but it is of great importance that the action should be even and regular, so that the boat may be kept evenly balanced. The beginning of the stroke is, with the sculler as with the oarsman, most important. Most important also that he should slide at the right moment, not too soon, but as soon as he has got hold of the water, not relaxing for an instant his grip, but carrying his whole body back by one effort, thus lifting his boat as it were over the water. His recovery should be even also, the hands dropping so as to bring the sculls cleanly out of the water. There should be no bumping up and down, which stops the way of the boat. He should not look at his toes, a common fault, but at the distant points upon which he can keep the stern of his boat so as to steer her proper course. He will often have to turn his head to avoid collisions on a crowded river, and he must learn Sculling.

to do this without endangering his balance or checking his pace.

We have dwelt upon rowing in its relation to racing craft, chiefly because it is in these that the highest exercise

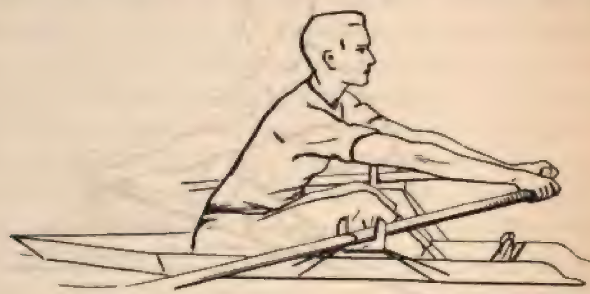

FIG. 5.—SCULLING. FIXED SEAT—FORWARD.

of the art is to be found. But for those who do not aspire to race, there is no more healthy exercise than rowing, none more full of pleasure and variety. Even

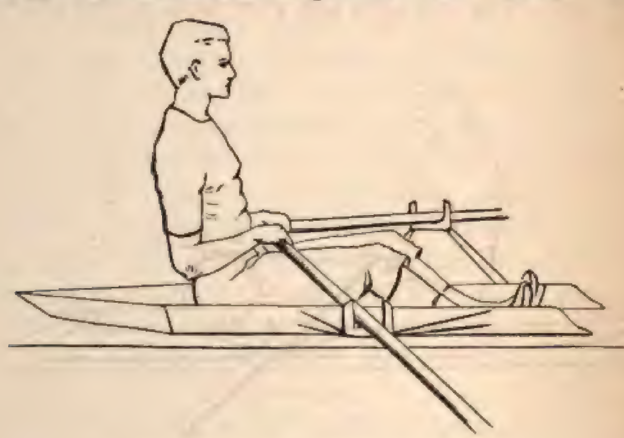

FIG. 6.—SCULLING. FIXED SEAT—BACK.

these will desire to know how to row, and should try to learn the art, so as to be able to apply it in practice without exhibiting ungainly form, or ludicrous efforts. To row correctly is to row with ease, saving thereby much

unnecessary labour, and much discomfort. Pleasure boats and their fittings are now for the most part so much better and lighter than those in which our fathers rowed

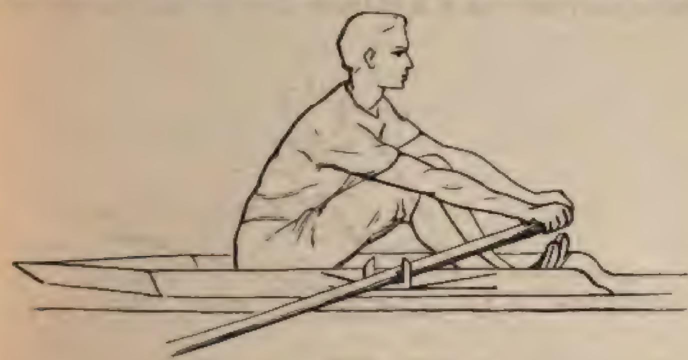

FIG. 7.—SCULLING. SLIDER—FORWARD.

their long races from Westminster to Kew, that the exercise has become much more inviting than it was in their day. The railways also give facilities for reaching

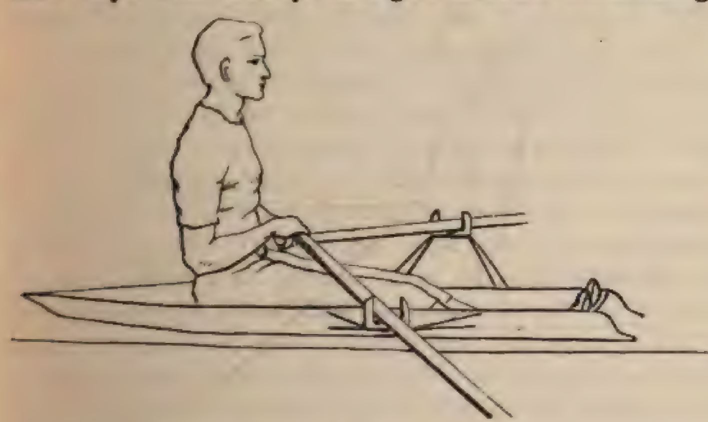

FIG. 8.—SCULLING. SLIDER—BACK.

water on the Thames and other streams, where boats are plentiful, and the charms of river scenery inexhaustible. What better recreation can any one wearied with brain work and the cares of business desire?

Canoeing. Though the regular oarsman may affect to look down upon canoeing, yet Mr. John McGregor, in his popular books, has shown how in a little vessel of the kind great distances may be travelled, and great enjoyment be obtained. Far, therefore, be it from us to speak with anything but respect of canoeing. As a muscular exercise we prefer rowing and sculling, but still for those who do not, the next best thing, as far as exercise on the water is concerned, is to paddle a canoe.

Swimming. The danger of upsetting, which is hereby suggested, makes us inclined to say one word with reference to an accomplishment of great importance to those who take their pastime on the water, viz., swimming. More people know how to swim now than formerly, but still many of those who habitually frequent the river do not.

The swimming baths now established in the Metropolis afford opportunities for learning the art, of which many boys and young men might avail themselves. The rule established at Eton in the year 1840, by the exertions of that great and good man George Selwyn, afterwards Bishop of New Zealand and Bishop of Lichfield successively, under which boys, before they are allowed to go out in boats, have to *pass* in swimming, has been effectual there in the prevention of fatal accidents, only one case having occurred since that time, though swamping, as may be believed, is very frequent. Every year, on an average, about 150 boys learn to swim and pass the test. Though it would not be possible to enforce any such rule except at a school, yet the success of the system that has been thus in force for more than forty years suggests the idea that a good work might be done if public swimming baths could be still further multiplied, and if some encouragement were given to lads to pass a similar test. Many of the catastrophes which now turn parties of pleasure into parties of mourning would be prevented thereby, and many a life saved.

CHAPTER VII.

TRAINING.

Necessity of — Books on — History — Object and practice — Diet — Exercise — Staleness — Bathing — Dress — Mental occupation — Sleep — Going out of training.

WE have already referred to the necessity of preparing not only the external muscles of the frame for any severe effort like a race, but also the great internal organs, heart and lungs, which supply the power and living energy by which the effort is made and maintained. Necessity of training.

Dr. Morgan, in his valuable work entitled 'University Oars,'* has treated the whole question of training for rowing with the knowledge which could be brought to bear upon it only by a medical man who was also himself an accomplished oarsman. He has shown how groundless was the idea, once common, that rowing in general, and more especially rowing in the University race, was the cause of disease, and premature death, to those who ventured to take part in such a violent exercise—such a suicidal contest! Out of 294 old University oarsmen he discovered that but about six per cent. were even said by themselves or by others to have been injured, and in most of these cases careful inquiry showed that neither rowing nor the race was to blame. The interesting book lately published by Mr. Treherne, giving the record of the University Boat Race, fully bears out this conclusion. Books.

While therefore we may fearlessly uphold the character

* 'University Oars,' by John Ed. Morgan, M.D. Macmillan. 1873.

of rowing as a healthy pastime, it will not be out of place here to point out that in rowing, as in all athletic exercises, training is necessary if any great and severe call is to be made upon the muscles and organs of the body.

History. The history of training as known to amateur oarsmen of the present day is interesting as showing the persistency of a mistaken notion, in matters of diet and exercise, when once it has been admitted. Thirty years ago crews in training were the victims of a system based upon a fallacy, and suffered much discomfort in religiously conforming to that which was no better than a groundless superstition. Any amount of under-done meat with stale bread, but hardly any vegetables; a severe restriction as to the quantity of liquid, while, as to quality, strong beer was prescribed as strengthening, and nothing else believed in; hard running in the morning, and on an average sixteen miles of river-work in the afternoon; such in respect of diet and exercise was the fate of oarsmen at the universities, and we believe also in the Metropolitan clubs that then existed, though probably they were less under the dominion of absurd rules. All this arose from a mistaken notion as to the nature of training. It was a system copied from the training of professional watermen and then still further exaggerated. But a waterman in those days, except he was in training, hardly ever touched meat. Beer no doubt he got, but not of the best. Vegetables, except potatoes and perhaps onions, he rarely saw. His training, to get into condition if he was backed for a race, was a period of unusual luxury for him, and he was not very particular about his meat being well done. And so it came about that when inquiry was made by admiring amateur oarsmen of Bob Coombes or Chambers as to what they did in the way of diet, the information received was regarded as a recipe, and its practice ordained by rule. A little reflection might have told us that the waterman's antecedents as to diet were not the same as an amateur's, and that the training of the latter should be "with a difference." After suffering much from boils, etc., some of us did reflect, and a

more rational system was introduced into the training of University crews about twenty-six years ago. Since that time the whole subject has been thoroughly treated by competent authorities, and no one need now be ignorant of the right practice of training, or of the sound principles upon which it is based. The books of the late Mr. M'Laren on 'Training in Theory and Practice,' and of Dr. Edward Smith on 'Practical Dietary,' give all necessary information on the subject.

Object and practice of training.

The main object of training is good health and fitness for a particular kind of hard work. Diet and exercise and sleep and clothing have to be considered in relation to it. While referring to the works above mentioned any one who wishes to master the subject in its details, we may here give a few general rules which will be found useful to all who love vigorous exercises or care to excel in athletics of any kind.

In these as in greater things the poet's words are true :—

> "Self-reverence, self-knowledge, self-control—
> These three alone lead life to sovereign power."

The first maxim is, "Be temperate in all things." Do not, if out of condition, attempt that which requires preparation and training. Many a man has been foolish enough to be "dared to do" a thing which has cost him much more in life, and perhaps in death, than it was worth. To row or run a severe race, to attempt any feat with weights, or in gymnastics, while muscles and internal organs are utterly unprepared for the strain, is the act of the "*mens insana!*" These and the like are the things which cause strains and sprains and varicose veins, and ricks and aneurisms and cardiac dilatations, and other horrors. Therefore let any one who has any regard for a "*sanum corpus*" be so far careful of himself as to avoid calling upon it for efforts of the kind, if it has been living a sedentary life without any opportunity of getting into condition, or if it is convalescent from an illness, or if it is suffering for the moment from a cold, or sore throat, or cough.

Diet. The next point is diet. Let meals be regular and simple. As a rule, do not eat or drink between them. If you wish to get into condition, avoid things that are not easy of digestion. As a rule, at meals eat before drinking. Let breakfast have its tea and bread-and-butter, and egg or fish boiled, or chops or steaks, etc., and a little marmalade to finish withal if you please, but do not make it too heavy a meal. Let luncheon have but a spare portion; half-a-pint of good wholesome bitter beer, or, if accustomed to it, a glass of sherry (better without wine, if not your habit, in the middle of the day), and bread-and-butter and, if needed, some good jelly. We are supposing the hard exercise to be taken in the afternoon. Let dinner have its due variety. Fish (boiled, not fried), fresh meat, plenty of boiled vegetables, rice, sago, tapioca, any light puddings. For dessert a couple of figs or an orange, and some dry biscuit and one glass of good sound wine may be allowed. At dinner drink not more than two ordinary glasses of beer, or claret and water if preferred. Avoid things fried in butter or dripping. Avoid all greasy things, all raw vegetables, salads, and the like. A few watercresses, and in summer a few strawberries may be allowed at breakfast.

Exercise. As to exercise, the amount necessary must be determined by the nature of the contest in view. If you are going to row a race it is necessary to take running, or, at any rate, sharp walking exercise, so as to give the muscles of the legs their tone, as well as to improve the condition of heart and lungs. This work should be done in the morning, but not overdone, and it should begin with short distances and gradually be increased as the powers are developed. Vary the pace, and after running walk quietly back home, so as to let heart and lungs settle down to normal work after the effort of quickened motion.

The amount of rowing to be done must be determined by the trainer. If it is a four or an eight, he has the double business of individual and collective teaching to do, and can so vary the work of long-boat and gig practice as to adjust the necessary amount according to the require-

ments of his crew. In this, experience must be his guide. He should avoid overtaxing his crew by long rows at first. He should remember that the strength of a chain is to be measured by its weakest link, and that as to long rows, what the weakest man in the crew can do with safety must be the measure of the amount he requires from the whole crew. To knock the one up, though the other seven may be benefited, is tantamount to throwing away the chance of victory. On the other hand, it is quite possible to err in letting a crew do too little, as regards both pace of stroke and distance. No absolute rule can be laid down in these matters. They require for their determination vigilance and care and patience, and not unfrequently some courage to do the right thing.

If men become stale, change diet, course of exercise, and if possible air, by going to seaside or hills for a day or two. Staleness.

Men should weigh every day at nearly the same hour, and the weights be recorded in a book kept for the purpose, and carefully inspected by the trainer. He should also be well informed about any indisposition, tendency to weakness, boils, feverishness, sleeplessness or the like, on the part of any member of the crew, who should remember the Horatian maxim—

> "False shame of fools conceals their sores uncured."

After any exercise that has induced perspiration do not stay in damp clothes, do not stand about in the cold or in a draught. As soon as possible change, and get well rubbed down with a rough towel. This is most important, as the circulation is helped thereby, and the pores of the skin are thoroughly cleansed and free to do their work. If quite cool and pulses quiet, wash rapidly and dry thoroughly, though it is not advisable to bathe. It is not necessary to have such a horror of washing after exercise as watermen had of old. We remember an occasion on which, nigh thirty years ago, some members of a fine University crew were engaged in this operation after their row and run, when the waterman, a north countryman, happened to bring up the racing craft alongside the barge, and espying Bathing.

one of the crew at his ablutions, called out in horror, "Eh, mon, what are ye doing?" "Washing, Mat," was the reply. "Washing? Ye'll kill y'rsells!" Bathing should only be allowed in the morning, and then be limited to a plunge, a short swim, and out again.

Dress.

Men in training should as a rule wear flannel next to their skin, and take care that their boating jacket is well lined and warm. Catching cold after hard exercise should by all means be avoided and guarded against.

Mental exercise.

After the morning exercise and breakfast, and a short interval, occupy the mind with reading, and make it a rule to do what mental work you have to do to the best of your abilities. Men are apt to get stale owing to their whole mental as well as their physical energies being set on the race, and the preparation for it. This is a great mistake. Give the brain its due share of exercise, and you will row all the better for it. The mind at last gets sick and weary of the monotony of existence in training, and it most assuredly affects the body, and this often happens because men have not got self-control to apportion their time so as to give "*mens sana*" its fair share of the daily work. If they would do this conscientiously they would find themselves less excitable and less nervous as the day approached, more self-possessed, and quietly confident in having done their best for the honour of their *alma mater* or their club. Lastly, as regards sleep—men should get to bed not later than 10 to 10.30 P.M. and rise at 6.30 A.M. to 7 A.M. Some men require more sleep than others, but all should rest between those hours. In the country, where the air is good, sleep with your window open, but not so as to have a draught passing across your bed.

Going out of training.

And as you have gone into training, so in going out of training, be not precipitate. Athletics have had much laid to their charge very unjustly, owing to the folly of those, who by reason of lacking the "*mens sana*," have, after the race is over, maltreated the well-trained and "*sanum corpus*" by a sudden plunge into the vortex of unwholesome, not to say vicious, living.

CHAPTER VIII.

OTHER PASTIMES—THE VOLUNTEER SERVICE.

Archery—The rifle—Cadet corps—Volunteer corps in town—Drill halls—Standing camps in summer.

BESIDES rowing and cricket and football and bicycling, there are other athletic pastimes which may be mentioned here, though space forbids us to enter at length into their description. Fencing and boxing and wrestling, which were in vogue with our fathers, are less generally practised by the youth of the present day. On the other hand we have seen the introduction of la crosse and of lawn tennis, and the revival of golf in the south. Archery as a pastime is perhaps hardly so popular as it used to be, and has in the country a redoubtable rival in lawn tennis. Other pastimes.

It should not be forgotten that archery at one time was a part of education, and under the special protection of Acts of Parliament, by which the public schools were bound to exercise the youth in the use of the bow. The Shooting fields at Eton and the Butts at Harrow bear witness to this ancient practice. Archery.

The rifle has superseded the bow as the national weapon, and the volunteer corps at the schools in some measure, but not as yet at all adequately, fulfil the intention of the statute of Henry VIII. It is well that the three points of Persian education should not be neglected amongst us. Boys should still be taught to ride and to shoot, as well as to speak the truth. Riding is most desirable for them where there is the opportunity, and it can be afforded. The use of the rifles.

To learn the use of a rifle should be possible to all, through volunteer cadet corps established in all the large Volunteer corps at schools.

schools. At some schools the volunteer corps is already an established institution, and there can be but one opinion as to its usefulness.

If judiciously managed, drill and rifle shooting, and the other military exercises that can be introduced, such as field-engineering, bridge-building, signalling, and the like, can all be made interesting and instructive to boys and young men. Indeed, apart from the consideration of its educational effect, we think that the young men of the present generation are happy in having such an institution as the volunteer service open on them, wherein duty and pleasure, exercise and recreation, are well harmonised and combined by the patriotic spirit. In the Metropolis especially, and in most great towns, the volunteer corps give opportunities to young men for bodily exercise of the best possible kind. More, indeed, might be done in this direction, and the service made even more popular than it is, by giving frequent opportunities for physical exercise, especially in the winter time, to members of corps in drill halls specially fitted for the purpose, and in the summer much more might be achieved by the establishment of standing camps (*stativa*) for exercise easily accessible by rail, to the great benefit of the youth of large cities, and to the additional security of the country. But this of course would require help from the national funds, and can only be expected when the need is recognised, and its satisfaction demanded by strong and enlightened popular opinion.

Volunteer corps in towns.

Standing camps.

CHAPTER IX.

EXERCISE FOR CHILDREN—WOMEN—PERSONS OF MATURE YEARS.

Games—Formal exercises—Walking—Exercises for girls—Dancing—Rowing—Importance of physical exercise for women—Exercise to be kept up by older persons.

THE title of our Handbook is 'Athletics; or Physical Exercise in relation to Health,' and it reminds us that, though in dealing with the question of athletics we have been led chiefly to speak of them as the pastimes of boys and young men, we should be wrong in thinking that we had dealt completely with the subject if we omitted all mention of them in relation to the remaining five-sixths of the population.

Children's games. Children of both sexes are in need of physical exercise. This they naturally supply for themselves in play. As they grow and gain strength, they need watching in their play for the prevention of tricks and habits, which, if allowed to gain upon them, produce ill results physically. They should be taught to sit up and hold themselves up, not in any constrained posture, but simply and naturally. The rounded shoulders, slouching gait, head poked forwards, toes turned in in walking, are all capable of correction when taken in time. **Formal exercises.** The great danger when exercises of any formal character are required from children, is of laying too much stress upon one or other set of muscles, and for too long at a time. The exercises, if any, should be of the simplest kind, and with frequent changes, and intervals of rest. **Long walks.** Similarly long walks should be eschewed. Many of us can remember the tyranny of a walk in childhood; no loitering allowed—a

walk *there*, and as it seemed a very long way *there*, and a still longer way back again; while perhaps we were scolded for lagging behind, when exhausted nature was already dictating the change from exercise to rest, but the grim necessities paid no attention to her laws. In the country this is bad enough; but in the country there are wild flowers and objects of interest for children; whereas in London, pavement, and area railings, and shops, and then the park or the square, and then shops, and area railings, and pavement, and so back again! To each governess and nurse be addressed the invocation, "Be merciful as thou art strong in comparison with the little legs and tender growth of those whose physical exercise and recreation thou hast in custody." Let not the skipping-rope and the hoop be forgotten. For older girls and young women there is a need of physical exercise and recreation as well as for boys, but it is perhaps difficult to suggest any definite line which would combine amusement with exercise, and suit all girls alike. Dancing is excellent, and should form part of every girl's physical training. But then it is counted as a lesson, and is conducted indoors. It would be a great thing if, in the summer, dancing on the greensward were again in fashion, and graceful movement and social recreation of the kind were permitted in the light of the sun. But we fear that we have passed away from the days of such simplicity.

Dancing.

We are afraid that the young ladies of the present day as a rule sit indoors too long. Sitting up late at night, they do not care to go out or take exercise in the open air. We have nothing to say against needlework, but think that novel-reading as an indoor occupation is responsible for many weakened hearts and feeble lungs. How much better if they habitually went to bed betimes and rose early, and were accustomed to outdoor pastimes suitable to their age and strength!

Girls should run—yes, even run races together; should play lawn tennis or la crosse, and if they have the chance they should certainly learn to ride. Where there is a river, and there is the opportunity, girls should learn to swim

and learn to row. Rowing is an excellent pastime for them, if conducted in suitable boats with light oars or sculls. But the reflections of Father Thames, if audibly rendered, will say: "Beware, young ladies, of round backs and of crooked arms at the beginning of the stroke and of ungainly turning out of elbows at the end of the same. To row gracefully is to row well, for what is required in your case is not a very great amount of work in the water, but the graceful performance of that which is within your power." There are these, and no doubt many other games and amusements which girls and young women can engage in to the strengthening of their physical powers and to the improvement of their general health. Looking to the future this is an important question, as it cannot be said with regard to the health of the female sex, that the present habits of life leave nothing to be desired To quote the words of a most eminent surgical authority: "Whatever arguments may be used for athletic games for men and boys, they are as applicable for women and girls, subject only to what may be deemed a reasonable selection of games. The one sex need as much as the other both the bodily and mental training which are supplied by our active sports, especially by those which are practised in the open air, and which are very imperfectly supplied by any system of drill, or any set of gymnastic exercises supposed to be scientific."

Rowing.

Importance of physical exercise for women.

The generations to be born, however healthy and active their fathers may have been by reason of good physical exercise and healthy training, will not be otherwise than beneficially affected by their mothers having had similar advantages in pastimes suitable to their sex. They cannot but be injured by the habits of life and of dress which induce feebleness and want of vigorous energy, and too often an unhealthy tone of mind as well as of body.

But let us not be mistaken. We do not here advocate in any way the aping of what is masculine by the other sex, but rather such reasonable enjoyment of physical exercise and recreation as for them also may educate and maintain "*mentem sanam in corpore sano.*"

Exercise to be kept up by older persons.

We have already spoken of the athletics of maturer years, and therefore would only add here that the continuance of such open-air exercise as walking, riding, and even, after the example of the Emperor Augustus, of running and jumping, as late as possible in life, is more likely to keep up the physical energy, and to defer the decay of the powers, than the giving up of these things, owing to the increasing love of ease and disinclination to active effort, which as years go on is sure to supervene. Be young as long as you possibly can. Get as much fresh air daily as you possibly can. If your occupation is sedentary, and your brain is hard-worked, recollect that muscular exertion is rest and recreation, and restoration for it and for the digestive organs upon which it is dependent for its vigour.

CHAPTER X.

CONCLUSION.

Not mind or body apart, but whole man—Neglected by legislation—Need of open spaces—Board schools—Games—Difficulties—Athletic clubs—Importance of athletics to future of race.

Not mind or body apart, but the whole man.

THERE is a very wise passage from Montaigne's 'Essays,' which in the record of the University Boat Race is prefixed to an extremely touching and interesting account of the good work done for their fellow-men by several old University oarsmen who have now gone to their rest. Among these some were men of renown, such as Selwyn and Spottiswoode; others less well known, but still noble workers for good and for God among the poor and the sick, whether as doctors, like Townsend, or as clergymen, like Jacobson. These men were athletes in education, physical and intellectual—athletes in the vigorous and conscientious performance of the duties of their calling. It would be difficult to find better specimens, better products of healthy education and training. Such men and such women would be more frequently seen amongst us if our education conformed more generally to Montaigne's dictum. "I would have," he says, "the disposition of his limbs formed at the same time with his mind. 'Tis not a soul, 'tis not a body we are training up, but a man, and we must not divide him." Are we not apt to take and act with reference to education as if the mind had a separate existence from the body?—as if the man did not consist of the reasonable soul and flesh in perfect unity? And are not grave mistakes often made in the education of the young, may we not add in legislation upon education,

through want of recognition of this truth? It will be a matter of reflection to the future historian of the English people, when he has to treat of the educational legislation of the last forty years, that while such enormous efforts were being made and such lavish expenditure incurred for the instruction of children in the three R's, hardly a voice was raised in favour of improving the physical conditions under which this mental improvement was intended to take place, just as if the mind of the poor had been remembered, but their bodies forgotten.

Neglected by legislation.

Need of open spaces.

Of late years we seem to be awaking to the fact that open spaces and places for physical recreation are needful, but legislation has done little but that which conflicts with this need, by enabling the enclosure of spaces that used to be free, whereby commons and waste lands have been taken away from common use, and the very lungs of this over-crowded country contracted. It is only by the wisdom of wealthy corporations, such as that of the City of London, and by the munificence of individuals, that anything has been done to preserve or create spaces available for popular recreation. Burnham Beeches and Epping Forest will play a much greater part in the recreation of Londoners in time to come, when the advantage of such recreation is more fully understood. But there are many other open commons and pieces of waste land even more accessible, which might be made available for the athletics of the future, to the great benefit of the poorer classes.

There are two ways in which physical training might be brought home to the masses, to their great advantage and improvement.

Exercises at Board schools.

First, in regard to Board schools. A certain amount of drill and of gymnastic exercise, such as we have recommended in the case of private schools, might advantageously be introduced. And wherever it was possible, a play-ground, or separate playgrounds, for boys and girls, should be provided. Round these should be the running or walking paths with the distances marked, and there should also be the place marked for the broad jump, and a strong

vaulting bar and parallel bars provided. All these might be made, along with the drill and extension motions, part of the course of educational training, reducing or varying the hours of sedentary work, and giving the needful change to brain and muscles. The girls should also be taught to dance with suitable measures and rhythm, which might be accompanied by singing or instrumental music. This might be made, much more than is imagined at present, an instrument of culture and civilisation. We believe that the actual standard of mental work would be improved and not lowered by this combination.

Games, difficulties as to.

Secondly, as to games. These are more difficult to introduce and co-ordinate. Neither boys nor girls will play at games except such as are traditional and habitual amongst them. It is much more difficult to get football and cricket and the like played by boys who have not been initiated in them by the example of those immediately above them in age, than most people would think. It is recorded that shortly after the foundation of a great public school in the present century, the head master, a distinguished scholar subsequently raised to episcopal dignity, observed that, though the boys were attentive and well-behaved in school work, flagged, and that during play hours they were listless and doing nothing. He saw what was wanting. He called his masters together, and going to the cricket-field, took off his coat, and went bat in hand to the wickets; one of his masters bowled to him, and soon several of the upper boys came to join in the game. By degrees it was established and became popular, and few schools have produced better scholars or better cricketers since those days. Still the cricket was not spontaneous, any more than the scholarship, in its origin.

Boys' and young men's athletic clubs.

It would however, we admit, be hardly possible to introduce such games as cricket and football by means of the Board schools, but it is possible that by the formation of athletic clubs for boys, and athletic clubs for young men, in connection with missions and other institutions that might be inclined to lend their aid for such purposes, the

best kind of games might be popularised among the working classes. Every possible opportunity of securing open spaces that would be available for such recreation should be seized and utilised, and some facilities should be provided by legislation for the purchase of such areas for the good of the population. Legislation has abridged the sports and games of the populace rightly by interfering with brutalising pastimes. It ought *per contra* to assist in the development of healthy athletics among them, which would do much to civilise and to improve them both morally and physically.

Importance to the future of the race.

We should then perhaps find that gradual deterioration of the race arrested which has reduced the average male of some of the manufacturing districts to 5 feet 1·40 in. in stature and 106 lbs. in weight, which compares but ill with the 5 feet 11·28 in. and 199 lbs. of some of the country districts in this island.* The physical and mental and moral conditions of the masses of our large towns is an ever-increasing source of anxiety to those who look below the surface, especially as with the decrease of physical vigour they do not become less prolific, but rather the reverse, multiplying the inheritance of constitutional debility in their pale-faced, flaccid and degenerate progeny.

The year of grace 1884 will be a year worthy of a white mark in the national calendar, if the International Health Exhibition, while it promotes the knowledge of and the desire for better sanitary arrangements in houses, better habits in dress, and better diet, should also be able in accordance with its motto, to popularise, and, by inducing legislative and philanthropic co-operation, to make possible for the people all those athletic games and exercises which, individually and socially, are efficacious in the recreation and refreshment of the "*mens sana in corpore sano.*"

* *Vide* Dr. Morgan, 'University Oars,' p. 84.

ATHLETICS.

PART II.

BY

THE HON. E. LYTTELTON, M.A.

AND

GERARD F. COBB, M.A.

CONTENTS.

CRICKET, FOOTBALL, LAWN TENNIS, AND HEALTH.

CYCLING.

CRICKET, FOOTBALL, LAWN TENNIS, AND HEALTH.

"Health is that which makes the soul take delight in her mansion, sporting herself at the casements of your eyes."—*Dr. Channing.*

THE opening of this paper will consist of an assertion which may sound rather strange; that the people of England do not understand the value of games. If they did, it would be superfluous for me or any one else to write upon such a subject as Athletics and Health; and we may suppose that the need for the discussion of this subject shows that it is not yet understood. It is perfectly true that in comparison with other nations we do understand it; and that during the last twenty years the multiplication of cricket, football, and lawn tennis games, indicates an increased appreciation of their value. It is true also that by this time much attention is given to the subject. The newspapers cannot be accused of treating cricket and football with indifference, any more than the crowds can who throng to the matches at the Oval or at Lord's. But thronging to look on at a game is a very different thing from playing it. Reading the report of a county match will enable any one to hold forth to his friends, and say some very wise things. But the plain fact on which the assertion is based, is this:—If we really understood the benefits of outdoor games, there would be very few people who did not play them: whereas they are played even now by the merest fringe of the population. It is not to the point to say that the gate-money taken for the Australian cricket matches sends home each member of that fine eleven, with

enough to pay all expenses, and something to spare; or that so many special trains ran from Birmingham to Glasgow, carrying spectators of a coming football match. These facts only prove, what we all admit, that there is plenty of interest taken in games. But even now those who take interest are próbably a minority of the nation; and those who play are certainly a minority of those who take interest. There is a great deal of crickėt and football in big towns; but compare the number of men young enough to play with those who do play, and the proportion will be seen to be ridiculous. Now, the Marylebone Cricket Club is composed of members who at least take interest in cricket, and a very large proportion of whom are under forty-five years of age. The club is known to be large, affluent, and busy. It sends elevens about the country who help local cricket committees to keep things going by arranging matches year by year. On the Metropolitan cricket ground, Lord's, scarcely a day passes from May to September without a match being played. And yet what does all that amount to? In 1883, out of all that number of members, 2,875, only three hundred and four different individuals played for the club altogether, and only one hundred and eighteen on the ground itself.* This fact certainly shows what a fuss can be made by a large number over only a few performers. I have not been able to ascertain the number of men who play football at the Oval during the season, but should conjecture one thousand as the outside limit. Estimates on this subject must be very rough, but this figure would represent the number out of a population of about eight hundred thousand men in the prime of life, known to play once a week. Of course there are many more grounds round and near London, but taking all together there can hardly be more than four thousand Londoners playing football on any given Saturday during the season, in or about the town. Probably in other towns things are much the same, and in the country, Dr. Jessop tells us that a

* I am indebted to Mr. Perkins, secretary of the club, for these figures.

great effort is required to keep up a cricket club at all, and football prospers at present very little better. In short, though cricket and football are both called national games, can it be proved that more than one per cent. of men between twenty and forty play at either?

But this calculation, if so it can be called, does not touch the vast numbers of women young enough to take exercise by games in the open air. No one as yet proposes that they shall figure to any extent as cricketers or football players, but why, when it is theoretically admitted, that games are good for men, should we suppose that women can do without them? Lawn tennis is an excellent and priceless invention for those who can play it; but the game is too expensive to be within reach of the majority, and does not seem likely to extend itself to the middle and lower classes. Looking then at the entire population of the country, it is hardly too much to say that the practice of out-of-door-game exercise is confined to a small minority of one sex, though no one denies that the need of it exists for all.

But, it may be said, these remarks only mean that one form of exercise is practised by some, while other forms are in vogue among others, such as rowing and bicycling. Of course deductions must be made for each of these pursuits, and no one contends that a man should engage in them all. But the most liberal estimate of the number of those who derive health and amusement from these two forms of exercise, still leaves an enormous proportion of men, and nearly all women, who are content either with nothing, or with a walk when they can get one. For the present then let us leave out of consideration those who think that they can be healthy without any exercise at all, and confine ourselves to those whose only form of exercise is a daily walk. For, while very many people would say that they appreciate fully the necessity of out-door exercise, they add that it is nonsense to urge them to play games: they take a good walk as often as they can get one, and a walk is good not only for the muscles, but for the mind; they can talk out walking, and very likely

learn much more than by playing games. Moreover, professional work must be considered. "So many hours a day are spent at the counter or in the manufactory, and the remainder would be gone before a football ground could be reached. Life is not all play: we must work." Lastly, they urge infirmity and stiffness. "It is all very well to tell us to play football, but we are thirty years old or more. Before we had played for five minutes we should be ill, and several of our joints severely sprained. A walk is quite good enough for us; there is no necessity for us to cripple ourselves."

Now, to clear up the separate points contained in this statement is the object of this paper. It will be necessary (1) to discuss the value of exercise generally, (2) to show that games fulfil the requisite conditions better than taking a walk, (3) to indicate how the dangers attendant on playing games can best be met.

(1) *The Value of Exercise.*

I must preface my remarks under this head, by saying that I am not going merely to give the results of my own experience, but to rely for my medical information on two unimpeachable authorities, Dr. Andrew Combe, and Dr. James Cantlie.

The manner in which exercise operates upon the body may be briefly described thus: Something has to be done, and in order to do it a certain limb of the body has to be set in motion. The will of the individual acts upon the spinal cord, in some way apparently not yet clearly known, and the spinal cord communicates with the right set of muscles by means of nerves. That is to say, one nerve conveys the order, so to speak, to a muscle to contract, and another conveys a message back from the muscle to the spinal cord, and from thence to the brain, giving information as to how the muscle is performing its task, and whether it requires more stimulus or not. The effect of this transmission of the message from the brain to a

muscle is to cause it to contract just as an electric battery causes a limb to move; and the contraction of a muscle, which is similar to that of the body of a worm in motion, acts upon some bone, and so the limb is brought into play. For instance, the contraction or 'lumping' of the biceps moves the forearm up towards the shoulder. So far so good; but all among the muscles of the body lie the blood-vessels, some carrying red blood, and called arteries, others bluish blood, and called veins. Now the function of the arteries is to carry life to the muscle, just as it is the function of the nerve to set that life in motion. As soon as a muscle contracts, it draws upon the artery for more life, and the red blood in consequence comes hurrying up its channel more quickly than before. It nourishes the muscle, and changes colour, becoming waste blue blood, unprofitable for any muscle thereafter, till it has been cleansed. To carry the waste blood back to be cleansed is the function of the veins. They bear it along to the heart, and from thence to the lungs, where it is exposed to oxygen which we breathe, and again enters the heart, restored to its red colour, and charged afresh with life-giving properties, which it has received so quickly from the outer air. Thus the demand is made by the muscles. The arteries are squeezed by the contraction, and the blood courses along, first red, then blue. Hence muscular effort quickens circulation. It also quickens respiration. For the more dark blood is transported to the lungs, the more air we must give it, that it may become red again.

This is the process. What, then, is the use of it? We saw that red blood as soon as it has nourished the fibres of a limb changes its colour. This is owing to chemical change, and chemical change means heat. Now by heat the perspiratory glands, which are always acting, are stimulated to give out freely; and the result is sweat The value of this will be explained directly. The second result of exercise, which is less generally known, depends on the breathing apparatus. A healthy man breathes by moving his diaphragm up and down. This motion acts

directly as a stimulus to the kidneys, liver, and stomach, which organs lie just below the diaphragm. Hence, in exercise it is not so much the shaking of the body which helps the liver, as the quickening of the breathing from an unconfined chest.

These, then, are the two great results of exercise—perspiration and stimulus to the digestive organs. Most people have a good word to say for the latter, but it seems that the intimate connection between free perspiration and health is not generally understood. An observant man, who has once got into the habit of taking exercise that makes him sweat, soon finds what a wonderful secret it is of health and happiness, both to body and mind. Sweating is a way of getting rid of waste material in the body, which must be got rid of somehow. It is a "chucker-out," so to speak, as if the body were a lodging-house. The coadjutors of the skin in this beneficial work are the lungs, the liver, and the kidneys. The more work the skin does, the less remains for those organs to do; the more vigorously and easily will they perform their own tasks of getting rid of waste—be it carbon, watery vapour, or waste food. Hence sweating relieves the intestines. But more than that, it clears the head, as anyone knows who works hard up to the time of taking exercise, and begins again afterwards. How many gloomy humours and brooding cares have been dispelled by its genial working! How it cleanses a man's view of life, and leaves the body in a tranquil, purified condition, ready for mental labour, or nourishment, or calm sleep.

These are some of the benefits of hard exercise, which in reality so few people understand. Closely allied to them is the stimulus to digestion afforded by the quick respiration. Perhaps it is needless to dwell long upon this, though to one who reflects on the numberless sorenesses, acerbities, and daily trials which fall to the lot, not only of the dyspeptic, but of all who have dealings with them, and think how this incalculable addition to man's woes might be lessened if the effect of moving the diaphragm were

thoroughly known, it becomes difficult to pass the subject by; difficult also to imagine why we worry about so many subjects of infinitely less importance.

But space forbids eloquent language even on this theme. We have now to show (2) *that games fulfil the requisite conditions better than taking a walk.*

Many of us are aware that a good game is a pleasanter thing than a walk, but few of us know that it is, *for that very reason*, more health-giving. Enough has been said to show the intimate connection between muscles and nerves. Let us listen then to Dr. Combe. "The simple fact that the muscles exist for the purpose of fulfilling the commands of the nervous system, might of itself lead to the inference, that a healthy mental stimulus ought to be considered as an essential condition or accompaniment of exercise. Hence the superiority as exercises for the young of social and inspiriting games, which by their joyous and boisterous mirth call forth the requisite nervous stimulus to put the muscles into vigorous action; and hence the utter inefficiency of the dull and monotonous daily walk." Here then is the secret. If the will forces the muscles to work while the nerves are not naturally stimulated, fatigue indeed will result, but fatigue alone is not the object of exercise. Even if the two great benefits spoken of above are secured, it will be at the risk of depression and exhaustion. Otherwise an hour on the treadmill would be as salubrious as a game of football; but, without having tried that form of exercise, I can safely say that it is not. Hence a walk in a new country, or with a pleasant companion, is by far more wholesome than a dull one along a well-known road, since when interest is felt the nerves are naturally stimulated to set the muscles in motion. Hundreds of stories are told of the increased power of muscles under nervous stimulus. It is doubtful if even Dr. W. G. Grace could have run 12,000 yards on a boiling hot day in August, wearing heavy pads and carrying a bat, had there not been twenty-two men round him trying ineffectually to get him out. But the delight of baffling their best endeavours, and

the recurring satisfaction of doing what he liked with the ball, made such an effort a mere constitutional to him, save that his appetite was keener in the evening, and his sleep more sound, than it would have been after any walk.

My authority tells also the excellent story of an Englishman who fancied himself too ill to stir, but was prevailed upon to travel from London to Inverness to consult an eminent physician. His expectation of a cure enabled him to bear the journey northwards, and his wrath at finding that the eminent physician did not exist sustained him all the way home so well, that on arriving he was nearly cured. Plenty of people know these things, and yet they wonder why a mile walk along a dusty road, talking stale gossip, should tire them more than getting a hundred runs.

This, then, is the first reason which we should do well to remember. Games give a nervous stimulus; an ordinary walk does not. But there is another reason, something like it. If any doctor were asked what the chief causes of overwork were, he would say, first, excitement, and second, monotony. Moreover, it seems to be generally held by eminent men, that work pure and simple, which is neither very monotonous nor very exciting, never yet did any one serious damage. That being so, is it not absurd to suppose that a walk with a friend—which is perhaps better than a walk without—can give the required relief so well as a game which absorbs the thoughts and interests for the time? The question is, what do the friends talk about? And too often, it must be answered, they talk about the same work which has been absorbing them all through the morning, or, indeed, all the week. They repeat jokes which have all the old savour of the counting-house, or the mill, or the brickyard; and if monotony is that which makes their work dangerous to them, their very recreation only adds to the danger instead of diminishing it. If, then, a walk with a friend even along a country high-road is to be condemned on these grounds, how much more the dismal perambulation made by some business men from Russell Square to Gower

Street twice a day, with money-making in their thoughts for every yard they tramp; with work behind them and before them; while the only faces they see are "sicklied o'er with the pale cast of thought"—thought about money, ledgers, and frauds? This walk is better than the Metropolitan Railway. But we may recommend any one, who supposes it to be good exercise, to disabuse himself of the notion as quickly as may be. Lastly, if this cannot be recommended as a health-giving process, what are we to say of the slow saunter about the streets, fondly mistaken for exercise by many able-bodied men? A walk, however dull, and however oppressed by care, may at least warm the feet, and quicken circulation a little. But a saunter does nothing whatever but increase the risk of catching cold. It is a deplorable waste of time in many cases; and being a mere exposure to the weather, may do mischief where benefit was expected.

Compared with all these, how splendid a thing is a game! The rush, the turmoil, and the perils of football, will lift the gloomiest cares away from the soul, be it only for a short season; and what stagnation of spirit is not overcome by the continuous delicate interaction of nerve and muscle, which is essential to getting fifty runs, or by the concentrated joy of making a good catch? Endurance, courage, steadiness, rapidity of decision, temperance of living, cheerfulness, unselfishness, readiness of submission, or power to command—these are faculties we none of us can afford to neglect, and every one of them is directly promoted by the two finest pastimes ever invented by civilized man!

But we must not forget the women of the country. If we were to do so, we should only be following in the wake of many a writer and preacher whose theme is the future of England, and who seem to have forgotten that the vitality of her sons must have something to do with the health of her mothers. Even in these days, when every error has been dispelled, and the mists of barbarism are finally rolled away, this subject has barely come up for consideration at

all. Miss Cobbe and a few doctors have from time to time uplifted their voices, with very small success. Why don't girls take exercise? Without any desire to overstate the case, we must acknowledge that common sense on this subject is not very common yet. Provision has hardly been made to meet the need, and the only reason that I can suggest is this. Girls are far more uncomplaining than boys. The British boy, who is being overworked, has shown a fine power of entering a protest, which sooner or later wins him his object. Permission has been given to boys to play, because after a certain time no one can make them do anything else. With girls the case is different. They do what they are told; and where disobedience would make them healthy, they obey that they may become wise. Whether they attain this latter object has always been a matter of dispute.

But the quiet submission with which (compared to boys) the joys of robust health are surrendered has, surely, its origin partly in their dress. Contrast the two sexes. There is very little to give any sign to a man-child that life is not all a merry-go-round, till the moment when he first begins the elements of grammar and the definitions of parts of speech. From that moment an influence has been brought to bear upon him, against which he wages a vigorous and unremitting war. But a little girl is early led to believe that life is indeed a burden, from the moment that she begins to "set up" her figure with corset and stay, a burden which no protest will ever lighten, but which she and all her sisters in civilized Europe are destined to bear to the grave.

Nothing could more effectually teach a lesson of unconditional submission to the ills of "little health" than this early imprisonment, and to it we may ascribe the fact that women are found to clamour for votes and for science lessons, but to think that a walking-tour and a hearty breakfast are better left to the other sex.

I have, however, through the kindness of the Vice-Principal of Newnham College, Cambridge, been fur-

nished with some remarks on this subject which I transcribe:

"Certainly my opinion is very clear as to the great advantage of good, healthy, active exercise for girls and for women, and as to the need for more of it than they usually get. And I think that active games and athletic exercises, while as necessary for girls as for boys, need more 'protection' in the case of girls; with boys they seem to flourish naturally, the excitement of matches and the possibility of attaining excellence, making it unlikely that their interest should flag; while with girls, from their much more variable health, matches are a difficulty, and from their smaller muscular strength it is harder for them to attain excellence; and altogether they are more likely to be physically somewhat indolent, or at least to have less unflagging energy about their games; also girls are, as a rule, poorer than their brothers, and so less able to meet expenses which are not considered necessary, and they are more dependent than their brothers, and so less able to join with outsiders, and take walking tours, etc.

"So it is much to be hoped that active games and exercises will be distinctly promoted where girls congregate, and especially in the High Schools which are now taking so large a share of their training. Playgrounds should, if possible, be provided for *all* schools for the young. It is, no doubt, true that very hard bodily exertion is not good with very hard mental exertion, and it is obvious that bodily exertion may very easily be overdone. But, in the case of girls, these things seem to make us forget, that *sufficient* physical exercise is not only pleasant to mind and body, but essential to their healthy development.

"Gymnastics are excellent for young girls. Older girls might use them much more than they do, though no doubt with great care. There is a scarcity of active (as distinct from pottering) games suitable for girls, i.e. which are not too rough and too violent; but lawn tennis is in every way excellent for them, whether to play among themselves or with men. This game is of very great use and pleasure to

students of Newnham and Girton ; they play it all the year round, and never seem to weary of it; it is very strongly to be recommended to all young women who lead a sedentary life. Fives is an excellent game for girls among themselves, and it is a great pity that it is not more used by them.

"As to dress, the one essential point is that it should be quite loose ; it should be of some woollen material, and not made heavy with too many folds and trimmings. Any over-skirt should not reach to the knees. The most suitable and comfortable costume that I know of for lawn tennis, skating, mountain-walking, etc., is a gymnasium costume, with the addition of a plain and fairly full skirt. Shoes or boots should, of course, have either no heels, or only low square ones."

The wisdom of these remarks is surely beyond dispute. If they or any similar warnings fail of their effect, the reason must be that the public are tired of them. Those of our countrymen who see the importance of such matters, not unfrequently preach about them to the risk of becoming wearisome to "the general." But this only means, that warnings are disobeyed because they are so obviously true as to be dull.

The hygienic interests involved in women wearing sensible boots, are no doubt unimportant compared with those which are imperilled by foolish fashions of stays. But they are serious enough. Tight boots cause chilled feet, and chilled feet may cause anything. But the real truth is that tight boots prevent walking, much more running ; and therefore this strange desire for a supposed ornament is indulged at the cost of an enforced sedentary life. It is a mistake to think that the outcry on this subject has produced much effect. Probably the most trustworthy witness on the fashions of ladies' boots that could be found, would be one who pursued the unambitious calling of a chiropodist. One who enjoys a large practice in London has given it as his opinion, that though it is less common to find heels made in the centre of the foot than it was, yet

the boots worn by ladies are tighter than ever. The chiropodist sees nothing objectionable in this, but others may. It would appear to them that on this subject sound sense is thoroughly worsted, and they might as well give up preaching any more. Others, again, might find consolation in the supposition that women have at last ceased to compress themselves tightly round the waist, and that their instinct for injuring some portion of their frame is now satisfied in a less injurious manner. This comforting theory is, I believe, contradicted by facts. In the twelfth edition of Dr. Combe's 'Principles of Physiology,' published in 1843, no one would be surprised to find the very gravest warnings given in regard to the "false and most preposterous taste" shown by tight lacing. It would be supposed that in any more recent book such a treatment of the subject would be out of place, owing to the healthy change in fashion, brought about by enlightened opinion. The reader's misgivings, however, might be aroused by finding the same warnings repeated in the fifteenth edition (1850); and if he chanced to read the words of Dr. Lennox Browne, in his book on Voice,* which is only just out, he would be led to the conviction that, in spite of all the grave advice, all the hysterical warnings with which the public mind has been flooded for fifty years, this astounding folly continues as rampant as ever. It would be useless to add to the chorus, but let it be remarked that, for a girl to seek health by means of lawn tennis, when she has not ample room for her lungs, is a sorry waste of time.

We have now considered carefully the special benefits which belong to such out-door games as cricket, football and lawn tennis, and the grounds for considering them superior to those gained from more common forms of exercise. Most people admit the truth of this view, when it is merely a view; but since they so largely discard it by their practice, it will be best to consider the objections which may be urged, and which do certainly

* 'Voice, Song, and Speech.' By Lennox Browne and Emil Behnke. London, 1883.

lead many people either to abstain from games altogether, or else to leave them off early in life. They are objections founded on the dangers incidental to playing such games as cricket and football.

The dangers may be ranged under four heads :—

(*a*) The dangers to life and limb from accidents.

(*b*) The dangers of taking cold from over-heating.

(*c*) The liability to sprains from over-exertion.

(*d*) The liability to excess, when games are combined with severe intellectual exertion.

(*a*) need not detain us very long. It is perfectly true that where football is really fashionable there there will sooner or later be bad accidents. The excitement of the fray leads to violence—violence leads to broken limbs, and as we know, sometimes to loss of life. It is no use blinking our eyes to the fact, or quarrelling among ourselves as to which form of football is most dangerous. We may have our own opinion on the point, but there is no reason to publish it. The true defence of football against alarmists is to compare the number of its fatal or serious accidents with those which occur in the hunting-field, or among almost all pleasure-seekers, Alpine climbers, or cover-shooters, or sailing-boat parties, and so forth. Danger seems to add zest to an Englishman's recreation. Anyhow, the verdict of all who play football is that the gain is well worth the peril, and that verdict is pretty generally accepted.

(*b*) The dangers of taking cold from over-heating. In order to deal with this subject we must consider the question of garments and changing.

To change clothes after hard exercise becomes almost a necessity to those who have once adopted it as a general practice ; and yet it appears to be only of recent introduction. Let us take an instance. Most people would allow that the inmates of our big public schools are as advanced in all that relates to athletics, and the comfort of arrangements connected with them, as any portion of the community. But twenty-five years ago, though Eton and Harrow sent their representatives to play their annual

match at Lord's, clothed in spotless flannel, the remaining members of the schools were not indulged in the same way. The garments were worn by the selected players far more for ornament than as a hygienic necessity, and the remainder learnt cricket in cloth, that on some future day they might shine before the public in white flannel. Again, people in charge of preparatory schools always have been extremely careful in matters relating to health, and whatever precautions are generally recommended by doctors for those who take part in games, we find observed by these people with the utmost attention, so that in what is called sanitation the usages of the outer world are reflected with sufficient accuracy in the regulations of a high-class preparatory school. Now in one of these establishments at Brighton, as late as 1868, so little was this important question understood, that the children were only allowed to don flannels on rare occasions, and ordinarily played football in those garments in which they were to appear at dinner; if the weather was anything but mild, they were not allowed to take off their jackets during the game, a precaution which, as we shall see, must have defeated its own object. Hence we may conclude, that though the benefit of wearing flannel clothing during hard exercise is appreciated by a certain number now, twenty years ago it was a fact unknown to almost all. It is true that flannel has been for many years in England commonly worn next the skin, but the prevailing opinion seems to be that exercise in ordinary garments can be indulged in, and that no harm will result even if the underclothing is not changed. We must examine this opinion carefully, as it is very widely held, or, anyhow, acted upon.

It may be said at once that it is a common cause of colds.* It is well worth while to consider it in this light, because colds in the head are astonishingly frequent, and are constantly the beginning of worse evils. But in themselves

* The present writer is inclined to speak dogmatically on the subject of avoiding colds, as he once passed six consecutive years and a half without a cold in the head, which seems to be a rare experience.

they are no small addition to the ills of life. They blear the eyes of the body, and impede the working of the mind; and if, as their frequency leads me to think, they often spring from preventable causes, something will be gained if those causes are generally known. Now a cold in the head is one form of chill. A chill is the effect of insufficient circulation of the blood in the skin, which throws a disproportionate mass of blood inwards. This excites secretion in some internal organ, leading to more or less serious disorder. Now everybody knows that it is unwise to keep wet socks on the feet. The reason is simply that wet socks are probably cold to the skin, and check the circulation on the feet. If the wet socks are not cold, they will do no harm. A man may get wet through, and if he walks directly, he will be safe, not because he is dry, but because he is warm. Let us then consider the effects of perspiration, and the precautions to be observed. The moment perspiration begins, the temperature of the body is lowered. Heat passes out, and hence all sensible people take care to wrap up the skin after perspiring. But—and this is the point—when exercise is taken and the body has sweated, and the clothes are not changed, then a chill is, so to speak, solicited. It is flying into the face of danger; because the garment next the skin is moistened, the moisture cools, and in a few minutes even flannel may become quite cold to the skin, just as if the body were encased in garments wetted with rain. Hence the first and most necessary precaution against chills is to change the under-clothing after exercise. It is true that this cannot be done by everybody, but it is equally true that when it can be done it ought to be done Tried, therefore, by this test, outdoor games are beneficial against colds. The simple precaution of changing the shirt after a rapid innings at cricket, and before going out to field, will obviate all risk. Towards the end of the season, anyone who has to field out in the afternoon ought to wear a very thin zephyr under the shirt. This does not materially increase the heat, but it prevents the evening breezes from

playing too merrily round the ribs. A cricketer with a cold is only half a cricketer, and is pretty sure not to score. Football players are occasionally put to the most serious inconvenience by the absence of washing accommodation after a match. The hasty toilet of a dozen or more of hot and angry men in one room is a hideous incident of this noble pastime, hideous enough when there are basins, worse by far when there are none. We would recommend then any one to remember that a 'dry rub' is far better than no rub at all. It cleans the skin, and prevents choking of the pores. Hence, where there is reason for misgivings about the changing room, a player should secrete a towel in his clothes bag before starting, and be ready for any emergency. Another precaution worth mentioning for ordinary life, is to change the socks after exercise, not because the feet are wet, but because they have perspired, and lest the socks may in course of time become cold to the skin, as explained above. Lastly, no one can learn anything about the secrets of healthy respiration, without being desirous of using his lungs in the best way. The best way is to expand the lungs from underneath by using the diaphragm, not from above by heaving the shoulders. Diaphragmatic breathing, strange though it may sound, will keep the lungs in fine order, and is a secret of great importance to all who exert themselves in games, or who use their voice much. But I must refer my readers to the excellent work called 'The Voice,' alluded to above, and to the chapter on respiration therein contained. Hence, to any one who wishes to avoid colds, this advice may be useful: "Make it your aim to perspire freely once a day, out of doors. Change underclothing as soon as possible, and even after a walk change the socks, and see that you do not wet the feet again; learn how to breathe, and speak or sing 'without remorse of voice' as often as opportunity allows." A man who observes these directions, and has a good conscience, will spend very little on doctors.

(*c*) The liability to sprains from over-exertion. To an athlete, the first premonition of coming old age is to

sprain himself somewhere. A growing boy finds his muscles stronger each year as the football season comes round. He resumes football, say in October, and runs and pushes as he had done in the preceding February. But the efforts of the preceding season, which then taxed his sinews to the utmost, are now made with ease, and he increases them till he has again reached the limit of his strength. But a grown man cannot do this. Disuse during the summer has caused his muscles to degenerate slightly from their former state of efficiency. But the will to kick and jump and hustle is as vigorous as ever. His memory of former triumphs urges him to a sudden violent effort, and instantly the unprepared thews protest. One of them gives way, and he has to lie up for a season, and learn that he has passed the age when his muscles gain strength of their own accord; and that if he is to increase their efficiency he must prepare them, and train them as he would a horse. This is the reason why sprains are so common at the beginning of the football season among young men; and an eminent surgeon told me that at the beginning of the lawn-tennis season a vast number of cases came under his notice, of men of five-and-forty or less, with all the vigour of youth, but none of its elasticity, who had incautiously resumed lawn tennis, and came to him wondering why their knees had given way.

Again, nothing is commoner than to hear men of six or seven-and-twenty declare that football is a capital game for boys, but that they must give it up as they feel themselves getting too old. And so it comes about that while some men enjoy the benefits of fine out-of-door exercise till thirty-five or forty years of age, others, apparently quite as healthy, feel obliged to give it up at twenty-six. Their work however refuses to be given up, and in consequence they lose "tone" by degrees, and cannot understand why it is that the daily walk does not supply the place of football on Saturday afternoon. Something must be wrong here. It is highly improbable that while some men can play football up to forty or even fifty, there should be a

necessity for others to give it up soon after they have learnt how to shave. The secret, which to the one class is familiar and to the other quite strange, is that all violent work requires a little preparation. If the lungs are to be taxed, then the training must be gradual, as everybody knows. If the training is omitted, the strain of suddenly running continuously for an hour is very serious and acutely painful; it often produces sickness, and threatens the valves of the heart, and the unfortunate victim of this imprudence thinks that this is a sign that he is too old to play football. He is not too old, he is too foolish. He is damaging the beautiful machinery of his body by treatment to which any groom would shrink from subjecting a horse. But the necessity of preparing the "wind" for exertion is pretty generally recognised. What, then, ought to be done to prepare the muscles?

Perhaps among the commonest strain is that which causes either a gradually-increasing pain on the front of the thigh, or a sudden snap of a muscle in the back of the thigh, just on the outside of the big prominent tendon which runs from the centre of the thigh to the back of the knee. These two strains are caused by sudden kicking or running. The first is well known among football "cracks," since the muscle which is strained is the rectus or straight muscle (running down the front of the thigh and attached to the kneepan), which is suddenly contracted in the act of kicking. But it is also strained by constant running on heavy ground. The pain comes on gradually, but is soon sufficiently severe to enforce rest. A lump then forms towards the top of the leg, about the size of a racquet ball, and very hard to the touch. This sinister object has terrified many an athlete into thinking that crippledom for life is now setting in. But he need not be alarmed. It is the effect, apparently, of one muscle taking the place of another; and, anyhow, there it stays, but the thigh with care soon becomes as strong as ever. The best way to prepare the legs for football is to exercise them by kicking the air, in private, just before the game, for the space of some five

or ten minutes. It is as well not to do so in a crowded street, as the movement is highly ungraceful, and might be dangerous to passers-by. But it should be done somewhere, as nothing is more effective in strengthening the muscles. It is a proceeding adopted, I am told, by ballet-dancers and acrobats every night, just before they appear in public to delight vast audiences by their supple strength. If this should not prove sufficient, then the thigh should be tightly bandaged previous to playing, either with an elastic bandage supported from the hips, or by yellow plaster. Rubbing the muscles is also beneficial, with the bare hand, a process known as shampooing, or with green oil. Those pattern athletes, the ancient Greeks, used this substance as a preparation for wrestling, firstly, to temper the effect of a hot sun on the naked body ; secondly, as a defence against the clutch of the adversary ; but thirdly as a lubrication for the muscles. The practice was adopted recently by a team which won the Association Challenge Cup.

The second kind of strain mentioned, that behind the thigh, often arises from running suddenly on hard ground, such as a running path. The precautions are to some extent the same as those which should be taken against more ordinary strains, and as a rule a plaster bandage restores the use of the leg very quickly. But a runner should never think of practising on a cinder running path at full speed for a day or two ; and if this caution were observed the strain would never occur at all. Just the same rule holds good about throwing the cricket ball. Begin gently, and increase by degrees. Again, sudden stooping often does harm. A cricketer on the wrong side of five-and-twenty, who wishes to keep up his fielding, should practise stooping for two minutes on getting out of his bath in the morning. I have known fives players adopt this method, with success, as a means of retaining their suppleness of limb.

(*d*) Liability to excess when games are combined with severe intellectual exertion.

There can be no question that this is a real danger ; but

it appears to be on the whole overrated. It is a danger confined to a very small class, for this reason. We found that physical exercise demands nerve-stimulus, otherwise the muscles will not contract; or, if they do contract, the red blood will not be sent in sufficient quantity to nourish them properly. Therefore it must be borne in mind that severe bodily exertion exhausts the nerve power of the body, not only the muscles, as if they were distinct from the nerves. Further, we saw that the brain was the seat of the nerve force, from which messages were sent to the muscles. Therefore violent exertion added to mental excitement causes the nerve power to be doubly taxed, and the result of that must be exhaustion. But be it noticed, that a vast proportion of what is called mental work nowadays, is not mental excitement at all. It is a deadening of the mind more than a stimulus. Where is the mental stimulus in the work done by a clerk, or an accountant, or a door-keeper, or a dispenser of railway tickets, or a hundred other officials whom we could ill spare? Work done mechanically is often called drudgery. Now drudgery is very abominable, but it does not exhaust the nerve stimulus. The reason why few men like to read a stiff book after sitting at a desk adding up figures, is not because their brains are tired, but because reading is sedentary, and their constitution calls out for motion and fresh air. But the work done by a man under strong excitement is very different from this. Young men in for stiff competitive examinations are working in a way that does tax their nerve power, and we may say that for them and them only hard exercise is injurious. It is perfectly true that after sitting and reading, they, like the clerks, ought to indulge themselves in motion, fresh air, and above all in some occupation that distracts the thoughts. All this points to a game; but the game should not be a violent one as long as the mental excitement continues. Lawn tennis or fives are excellent for this purpose. However, though competitive examinations are spoken of as universal, the number of men whose nerves are really very

being much insisted on. He is on his way to a green old age, and is perfectly content to continue with closed pores, if his income is tolerably secure, and his children are sent to a good school. The country clergyman says something of the same kind; so does the lawyer and a score of others. "It is all very well for those who can do it, but we can't." Some gentleman who has travelled has more to say yet. He bids me take into consideration the vast and mighty empire of Germany, built up by men who know not a scrimmage, or a long day's fielding out. How can it be necessary for us to make such a point of athletics, when the most powerful nation in Europe does without them? These considerations demand a paragraph or two.

I would first, then, call attention to a delusion which is very prevalent, and which underlies many of these assertions. It is that the human frame adapts itself to a life without exercise just as well as to one with exercise; to a condition of not playing games just as readily as to an athlete's life. This is not so. It is true that you may deprive your body of exercise, and after a little time you will cease to feel that imperative need of it which a man in perfect health feels if he is by some chance deprived of his accustomed game. But this only means that your body is in a lower condition of vitality. It is perfectly easy to lower the "tone" of the constitution without being aware of it. The native of a slum in Bloomsbury is certainly less robust than a Yorkshire gamekeeper. But he is not reminded of this fact day by day. He feels the same as usual, and that is all he knows about himself. The questions he ought to ask himself are, What kind of old age is awaiting him? Are his children healthy? If not, is their sickliness to be traced to their father? Lastly, can he do his daily work as efficiently and rapidly as if he were a healthier man? This last surely touches the point. No one can deny that hard-working men have obligations and duties which must be fulfilled before they can afford to consult their own comfort. A country clergyman would be a sorry minister indeed who put off a visit to a dying

parishioner, because it was the hour of his daily game of lawn tennis. Business men and lawyers and tradesmen and the vast tribe of operatives have their engagements, which must be met: modern society has given this folk their place in a huge machine, which works away, and requires that they work with it, keeping time to it, and thinking of little else. The machinery of life is getting more irresistible, and obedience to its claims may often be inevitable. When it is a question of "getting on" and buying a villa, and going to Paris, no one can expect such a trifle as bodily health to enter into calculation. But I am concerned with those who wish to do good work in the world, and who have time to think if they are setting about it in the most sensible way. Granted that they gain the two hours for work, which they are urged to give to play. Does that really mean increased efficiency of work in the long run? How is it possible that the lowered vitality should not tell upon any work which is not the veriest drudgery, and unworthy of a human being? Think for a minute how exercise, or the want of it, affects the whole being of a man. The non-commissioned officers who were trained in Mr. McLaren's gymnasium, in order to become gymnastic instructors to the army, increased in chest girth and muscular development in the most extraordinary way, one of them as much as five inches round the chest in four months. What does this mean? A larger cavity for the lungs, increased power of exposing the blood to the purifying action of the outer air, and in consequence a finer capacity for effort, physical or mental. Take again the words of Dr. Beddoe.* "If we examine only a single race or reputed race at a time, we shall find that whenever that race attains its maximum of physical development it rises highest in energy and moral vigour." He goes on to adduce as examples, the northern counties of England, which produce the finest men, and "yield more than their share of ability and energy for the

* Quoted by Dr. Cathcart, in his Lectures on Physical Exercise (3rd Series, No. 2, p. 33, of Edinburgh Health Lectures, 1882).

national benefit." Now is there any work which would not be better performed if the workman were to grow in "energy and moral vigour"? Dr. Channing hit the mark when he said, "Health is the working man's fortune; it lightens the efforts of body and mind, and enables a man to crowd much work into a narrow space." He means, in short, that any work of the higher kind such as demands a vigorous operation of the mind, judgment, forethought, assiduity, concentration, and so forth, would not only be done more efficiently, but more rapidly, and far more pleasantly, if time were always secured for recreation. And thus, in many cases the amount done would be the same, the quality would be improved, and with it the general prosperity of the individual. For, as it has been wisely said, it is not the work we do which exhausts us, but the work we are obliged to leave undone, or to do badly.

It seems then pretty clear, that if the effects of healthy exercise on all the powers of the human being, both physical and mental, were thoroughly understood, the whole difficulty as to want of leisure and opportunity, would in time be greatly modified. The system of society would gradually be altered to meet a growing need. In the course of time, conditions of life which exclude all time for leisure and recreation, would be looked upon as simply intolerable evils, which every sensible man must co-operate to stamp out. But the beginning would be made by those thousands and thousands of people, who now have opportunities, but are not anxious to use them. Above all, we should see a different life led by nearly all women. If women knew that a free circulation is as precious a boon for them as for men, they would revolutionize society: and yet what a wonderfully simple truth it is! They, as well as countless numbers of hard-worked men, would make opportunities. What is the use of his vote to the county householder, if he will not insist on securing room for cricket and football?

It is very little use for artizans to feel themselves a power in the Government of the country, and able to lift

up their voices, so that they shall be heard, unless they know what they really want. If they were to insist on leisure and football grounds, sooner or later they would get them. We all know that social forces are irresistible, but the fact remains, that if society knew its interests it would alter its own forces. Is it not a melancholy fact, that we have strained and struggled, and longed for things which are at best of very doubtful advantage, and ignore the plain old truths, that if we neglect our exercise, our vital force will diminish, and if our vital force diminishes, the country will sink in the scale of nations? Think for instance of the fuss made about education. If common sense had been allowed any play at all, should we ever have packed our little children into noisome rooms, filled with the reek of corduroys and hair-oil, and have rammed into their heads for three or four consecutive hours, the Bill of Rights, and the exact position of Hong Kong, without so much as giving a thought to their games, or providing them half-an-acre wherein to run about, and shout, and drink the air of heaven? What a marvellous stupidity is this! and yet it goes on. It is as easy as possible to find growing boys and girls of all classes, working nine or ten hours a-day, and their exercise left to take care of itself. It is thought that because a few dozen aristocrats play cricket to excess, therefore all boys and girls will provide games for themselves, make time to play, and space to play in. The truth is, that in education nearly everything is uncertain; opinions which differ as widely as possible, as to the claims of different studies, different methods, different organization of schools, and a hundred other questions, are raising a hubbub of lasting wrangle, in which theory and practice are mixed in dim confusion. One thing alone is quite certain, the priceless value of games for boys and girls. And yet the virtuous world of reformers and philanthropists has gone crazed over all that is disputed and obscure, and are leaving the one certainty out in the cold—partly, in the case of one sex, wholly in that of the other.

But we must not forget Germany. It is a stubborn fact that the Germans as a people apparently take very little exercise of any kind, and as a nation are the first in Europe in learning, industry, and military power. But there is nothing in this to weaken the claims of healthy exercise upon ourselves. Dismissing the hypothesis that though they are near of kin to us, yet there is something in their constitution which obviates the necessity for exercise—a hypothesis improbable in itself, and impossible to prove—why should we assume that they have reached the highest pinnacle of human power? Who can prove that they would not be benefited by increased attention to bodily exercise? Rumours reach us now and then of vigorous exertions being made by the central authority to introduce English games headlong into their schools, as an ingredient without which all their admirable teaching is maimed and defective. Serious difficulties have to be encountered. To start football is no light matter, even in an English public school: but when no one knows its delights, or its rules, it may take a long time indeed. The rapture of a scrimmage is an acquired taste, though a real one. But previous to the acquisition, the contusions and violent collisions might excite grave misgivings as to the beauty of the game. Therefore we must not be surprised at this reform taking time. But there is every prospect of its being started before many years are out, by means of closer union of the two countries, and the example set by English residents in University towns. But apart from this, we are wrong in supposing that the nation abstains from physical exercise. The military service ensures some opening of the pores, by requiring recruits to march thirty miles a day in full equipment; and it is as common as possible for university students to take walking tours with knapsacks, and spending surprisingly little on their daily food. Gymnastics are also enforced by state regulation. It would in short be much truer to say that young men in Germany already take some exercise, and are likely to take more, and that the whole nation will

benefit if they do so. Lastly, as regards their military prowess. If we consider the secret of those wonderful victories which sent a thrill over the entire Continent, such as had not been felt since 1815, we shall agree that it was not physical power, or endurance, or irresistible onset. These are things which hardly belong to modern European warfare. It was science which won the war of 1870, and to a great extent the science of one man. Coolness, practice, obedience, and profoundly calculated strategy, saved Germany then, and are now keeping the peace of Europe. But these are matters which need not enter into a discussion on health.

Still, however much we may deplore the prevailing abstinence from healthy exercise, no one can deny that the number who play these games is considerable, though the proportion to the rest may be very small. I will then offer a few remarks on the mode of life to be adopted by a cricketer, or football player, firstly, if he wishes to excel: and secondly, if he only plays on Saturday afternoon as a means of recreation.

Dr. James Cantlie, in the 'Book of Health,' lays down the most elaborate rules of diet for a cricketer who wishes to excel. They are minute indeed, and it might be hard to prove that one potato at luncheon is more wholesome than two. But in the main they are unquestionably sound, and yet even in their broad outline are habitually disregarded. Relying to some extent on him, and judging from experience, I would urge these as the most important. Go to bed not later than 11·30: get up sharp after waking, not later than 7·30. Eat a biscuit and drink milk or cold water at 8. Tea or coffee may affect the nerves, but I should not be afraid of them. Write letters, read or walk about slowly, till 10. Eat an ample breakfast. The importance of this arrangement of the morning is threefold. (1.) It prevents lying awake in bed, a most weakening habit. (2.) It is an admirable preventive of constipation which is fatal to clearness of eye. (3.) It prevents the batsman from going to the wickets between 12 and 2,

hungry. Nothing has lowered men's average more than the neglect of this rule. A biscuit and a glass of beer at 12 is worse than useless, and what is an Englishman if he is not fed? In really hot weather eat a good luncheon, as exhaustion may set in between 4 and 6, leading to what is called liver sun-stroke; a complaint which prevented Mr. A. P. Lucas from getting his 100 against the Players in 1878. Remember that the sun does mischief on the back of the neck, not on the top of the head, unless the head be bald, which is sometimes the case. *Eat a moderate dinner*, not later than 7·30. Almost the whole of the upper and middle class of England over-eat themselves at dinner. One help of well-cooked meat is enough, with fish and pudding. No cricketer should eat more. If he obeys this caution, he will wake up "with the spirits pure and vigorous, not only to vital but to rational faculties." This quotation leads me to say that for a healthy man, head work in the morning is quite possible under these conditions. He might rise at 7, and work from 7·30 to 10, and perhaps a little afterwards. Very few men will do more, and continue to get runs. Some will do a little in the evening, but very little. Still, any healthy man may work 2½ hours in the morning, and play all day. But he must go to bed early; he must drink next to no wine overnight; and he must be very moderate in his pipes. If his headwork is interesting, it will even help his cricket; since, if things go wrong, he will worry less than an idle man, and worry and dejection have often lowered the average in an unaccountable way.

At the beginning of the season, or indeed of each day, Mr. C. T. Studd recommends the use of Indian clubs, to train the wrists. Saturday players will do well to observe the above rules, as far as their circumstances admit. Of course they are prevented from any such regular life. They can counteract irregularity to some extent by a hard walk the day before the match, and by Indian clubs or any other gymnastics work off the effects of a high stool. But a man who sits still from Monday to Friday can hardly hope to score largely on Saturday.

Training for football is now thoroughly understood. The rule oftenest broken is that which places luncheon, chop, potato, etc., an hour-and-a-half, or two hours, before play begins. But, on the whole, I have nothing to add to what was said in the paragraph about sprains.

These simple directions I know to be, in the main, correct, and they are confirmed by more than one high authority. An athlete has little to do nowadays but to observe those laws, which everyone would do well to observe, did the conditions of his life permit. It will be seen how much modified the modern idea of training is. Nonsense about raw eggs, and red steak, is seldom heard. The cricketer has to adopt a perfectly natural, easy diet in order to be in good condition.

But, easy though it all sounds, this or any other prescription will fail entirely of its object, unless a few fundamental principles of health are more generally known and more consistently put into practice. There are cricketers, just as there are representatives of any other lofty vocation, who imagine that they can keep eye, hand, and mind in good working order, though they know themselves to be given to some form or other of intemperance. Is it likely that a man can put forth all his powers when he constantly goes to bed with his head hot with fumes of champagne, or his stomach loaded with excess of food? It is strange that men should delude themselves with thinking, that nerve and endurance can be combined with anything in the nature of coarse self-indulgence. A strange delusion, we must admit, but a common one. There are two other secrets which may be said to underlie all rules of health, that is to say, without which all observances will be quite useless—the first is pretty well understood, the second is hardly known at all. The first is merely the necessity of giving daily and regular *relief* to the system. Most grown-up people are aware of the importance of this, but most boys and girls are left to learn it by unhappy experience. Why do parents so seldom inculcate a little knowledge on these matters? Nobody knows.

The second, with which we conclude, is a duty to nature, which the vast majority of people are ignorant of, and most of the remainder omit to perform. It is the duty of chewing food. The veriest dullard who thinks for a moment on the daily task entrusted to our digestive machinery, how incessantly it recurs, and how serious are the issues involved in its fulfilment: and who has, moreover, learnt anything of the delicacy of those organs, and their close relation to happiness, will understand the need of lightening that task as far as we can, and the cruelty of any wanton increase of it. Our system asks for food well chewed and well lubricated, and we give it dry nuggets, at rapidly-recurring meals. The highest authority on disorders of the digestion and their far-reaching consequences, has said that no constitution in the world can survive the neglect of this duty. The difficulty of getting the truth believed is that the fatal consequences seem to have so little connection with their cause. They follow late in time, but with the most inevitable certainty. Melancholia, loss of sleep, lethargy, ill-temper, and a generally jaundiced view of life are among them, but are not the most serious. If anyone doubts the value of the prescription, let him try it. I could name a lad of nineteen whose whole life was exhilarated by this and nothing else. I could name a dyspeptic, who travelled in search of a cure all in vain, till a stranger told him to masticate his meat, and he obtained instant relief. But there is a better instance at hand than either of these. Mr. Gladstone is a man about whose physical vigour there can be no question. Men are known in troublous time to cavil at his statesmanship, but no one has anything to say against his digestion. Now as early as the year 1848, Mr. Gladstone formulated to himself rules for chewing food. Previously to that he had always paid great attention to this requirement of nature; but at that date he laid down as a rule for his children that 32 bites should be given to each mouthful of meat, and a somewhat lesser number to bread, fish, etc. It is also known that to get into a habit of following this example is as easy as can be. A little

attention paid to it for two days will ensure of the duty being unconsciously performed through life, with the most beneficial results. Truly, history turns upon small causes! The philosopher of future ages may busy himself with pondering what the course of the world would have been, had that number been 22 instead of 32. The answer to the question lies outside the limits of this paper, but the plain fact I leave to my readers' most careful consideration.

CYCLING

CONSIDERED IN ITS

RELATIONS TO HEALTH.

THE object of the following remarks is to discuss the question of cycling solely in its relations to health. No attempt will be made to give the history of its growth, nor to describe the successive stages of mechanical development from the barbaric infancy of the "dandy-horse," and "bone-shaker," up to the present civilised maturity of "roadster, racer, tandem, and sociable;" nor shall we venture to forecast the possible refinements and modifications of stages of expansion yet to come. Though we have already, indeed, been introduced to an embryonic form of amphibious cycle which can adapt itself to run on water as well as on land, to furrow the pathless waste of ocean as well as dint the metalled surface of the public highway; and although there remains a third possible element still unchallenged, and fan-wheels may hereafter be devised to plough the air as well as the sea, it will not serve the present purpose to enter any such region of speculation. We shall deal entirely with the cycle as it exists in general use at the present moment, and in referring to its different forms we shall throughout assume an average typical specimen as under contemplation. Neither will it be necessary to give any detailed description of the mechanical construction of cycles. A knowledge of cones, parallels, rollers, and balls, of spoon and lever, of

steering and of gearing, &c., however practically useful to the cyclist has little direct bearing on the hygienic aspect of his pursuit, with which alone we are here concerned.

Having thus clearly defined the limits of the subject, we will proceed at once to its consideration.

When the ordinary non-cycling spectator sees a good rider on a bicycle gliding quietly along a bit of smooth-surfaced roadway, with apparently the very slightest conceivable expenditure of muscular power, and that confined to an extremely limited play of foot and ankle, he is apt to think that there is absolutely no physical exertion in the process, that the machine almost goes of itself, and that to speak of bicycling as an "exercise" in the ordinary sense of the term is to indulge in culpable exaggeration. Such a description of it, he will say, may be tolerated in the mouth of an enthusiastic novice or an interested partisan; but it is not the language of reason and common sense. It is impossible, he will think, that the performance of real work can consist with that easy motionless attitude in the saddle, and that quiet smile of perfect comfort and composure, which are so characteristic of the practised bicyclist. Or if, again, he should meet another rider displaying a style of performance somewhat fashionable in the less refined and educated circles of cyclists, in which the legs from the hips downwards seem to be working up and down with furious and demonstrative persistence like a couple of animated pistons—in this case he may indeed change his mind and credit the rider with a considerable expenditure of energy, but he will still be inclined to suggest that bicycling exercises, after all, only one portion of the body, namely, the legs; and that on this account it falls very far short of the standard of ideal exercise, and that the very partial character of its operations in this respect will only justify us in describing it as an exercise of an inferior type to which a proportionately low position should be assigned in our Athletic Class List.

Such a view as the above is a very common, and under

the circumstances a very natural one, and there would be no possible object in alluding to it on the present occasion, were it not that it happens to be at the same time a most fallacious view, and that its fallacy consists in entirely ignoring one most essential feature of the exercise. To this feature we shall now invite special attention ; and it will be observed that in what immediately follows we shall be referring to bicycling only.

Those bicyclists who are conversant with many other forms of athletic amusement, and who have sufficiently vivid recollections of their first acquaintance with them to be able to recall their "learning" stage, will probably be found to be fairly unanimous in their testimony as to the exceptionally fatiguing nature of their initial efforts on the bicycle. Whether they required three, six, twelve, or even twenty lessons before they reached the stage of being fairly independent of external aid in the process, they will all bear witness to the fact that until that stage of independence was attained, the task of learning was a most severe one, that half-an-hour of it at a time was sufficient to exhaust their utmost capacity of endurance, and that so far from the feeling of fatigue being confined to the legs alone, it was co-extensive with the whole body. More than this, were they to be called upon to specify any particular portion of the body as being more obviously subjected to severe muscular strain than another, it would be the arms rather than the legs which they would single out for this distinction. The mere force required to *propel* the machine forms indeed a smaller portion of the entire muscular energy involved in the process of riding than is generally supposed. There are certain ingenious contrivances called "Home Trainers," the use of which is occasionally resorted to by bicycling enthusiasts for the purpose of keeping their "racing legs" in satisfactory condition at times when bad weather has made the normal form of bicycling unpleasant, if not impossible. Roughly speaking the machine is a stationary bicycle, *firmly screwed into the ground*, on which in response to the mechanical resistance offered, the rider is

enabled to apply to the treadles the same muscular force as he would be applying to them if riding along an average piece of roadway, whilst a dial for registering the revolution of the wheel enables him to ascertain exactly the imaginary distance covered by his exertions. In this case it is clear that whatever force is being exercised is of the nature of propulsion only. No one, however, would for a moment contend that the general physical condition of the rider and his perception of muscular exercise or fatigue is the same on riding a given distance at a given pace on "the Home Trainer" as that which he would feel after riding the same distance in the same time along a road where the state of surface and other conditions should be such as to imply an amount of resistance fairly equivalent to that mechanically provided in the fixed bicycle. The feeling of fatigue he would be conscious of after his ride on the road would be of a *far more general character*, and by no means confined to the legs. Neither would a person who wished to learn the bicycle find the difficulty and fatigue of learning very materially diminished, if before he made trial of what by a figure of speech we may perhaps be permitted to call the "living" machine he had a little previous practice on its inanimate counterpart. He might no doubt acquire a certain initial dexterity in the movement of his legs to which another novice who had not made trial of the "Trainer" might be a stranger, and it is also likely that his sense of fatigue in that particular locality would be slightly diminished in consequence; but in all other respects he would fare no better than the other; he would experience the same general "aching all over;" neither would his powers of endurance be found equal to a lesson of any decidedly greater duration than those of his companion learner. What then is the explanation of this very significant fact? It is this: the main feature in the exercise is not so much the *propulsion* of the machine as the *balancing* of it—the adjustment, that is, of the body in its application of motive power in such a manner as to secure an equal distribution of its weight on each side of the direct line of motion.

Now, in this process of adjustment almost the entire bodily frame plays a part, and the disproportionate fatigue experienced in learning to bicycle as compared with that involved in acquiring most other athletic arts is mainly due to the very comprehensive and intricate character of this balancing process, and the very large demands it makes upon new or comparatively unfamiliar modes of muscular action. It is this particular feature of the case which makes what appears to be such an easy and simple form of motion one really so difficult to acquire, and which also accounts for the very considerable variations in the period taken for its acquirement in different cases. Whether from differences of actual weight, or from the possession of some finer constitutional gift of muscular sense, it is undoubted that of two learners who may be presumed to start on a fair level of equality as regards general activity and athletic habit, the one will acquire his bicycling seat after far fewer attempts than the other. The same differences in rapidity of acquirement will be perceived in the case of two other exercises which to a certain extent afford a parallel to bicycling in the introduction of this necessity for accurate distribution of weight over and above the employment of actual motive energy, namely, skating and swimming; and it will generally be found that the same person whose period of probation is a short one in one of these cases will also show proportionate celerity of acquirement in the others. In each of these three forms of acquired motion another remarkable phenomenon may be observed, which clearly points to the very subtle nature of the process of acquisition, namely, that the power is almost invariably attained *all at once*—that it bursts upon the learner quite suddenly in the full plenitude of perfection without any apparent preliminary approaches to it. The learner feels, in fact, at the end of his 5th, 6th, 8th or 11th attempt (as the case may be), that he is no nearer the goal than he was at starting; he is entirely unconscious of any stages of *gradual approximation* to it; and just perhaps as he is beginning to feel disheartened at the obvious

absence of all tokens of progress, and inclined to give up the attempt from a feeling of disappointment or despair, he unexpectedly finds that the power of controlling the course of the machine has, as it were, dropped into his hands, and that provided the road be fairly smooth (so that no very disturbing application of propelling force is necessary) he can venture along by himself without further fear of failure. At this stage, too, he will notice that his attempts are followed by a diminished sense of general fatigue, and, in particular, that the strain on the muscles of the arm is materially lessened. The reason of this last is obvious.

Until the art of adjusting the weight of the body to the line of motion was acquired, the inevitable tendency was for the line of motion to adjust itself automatically to the weight of the body: hence the arms were being constantly called into requisition to apply the corrective process of steering, and to counterbalance *the weight of* the body, so far as its inclination deviated from the required line. But when once this art is attained, the counter process ceases to be a normal feature of the case, and the arms are no longer pressed into such strenuous service except under special circumstances in which owing to unfavourable conditions of road-surface, wind, or gradient, the amount of motive force to be applied is so abnormally increased as to partially interfere with this nicety of bodily adjustment, and thus necessitate some compensating application of steerage. For all practical purposes it may be assumed that the necessity for this strain on the arms varies inversely with the degree of accuracy and delicacy with which this newly acquired sense of balance operates, and under the most favourable conditions it even disappears altogether, as in the often-witnessed performance of riding straight along with the hands in the pockets, or even of making the machine describe a circle by the mere inclination of the body in the direction required. The work which would otherwise be done by the arms is transferred to the balancing act itself. Now, this act, which is due to the

continuous and ever-varying reflex activity of that portion of the central nervous system which regulates muscular movement, is one in the exercise of which nearly the whole body is brought into play; so subtle, so delicate, so complicated and all-pervading is the muscular energy necessary for its performance (an energy the acquirement of which makes, as we have seen, very heavy demands upon the physical resources of those who have to acquire it), that it assumes as it were an integral and permanent place in a man's constitution, and becomes a kind of new sense or faculty of which nothing can subsequently deprive him. Years may elapse without his mounting a bicycle and yet this power of balance will remain the same. He may indeed find his first ride after a long abstinence a *fatiguing* operation, but the old feeling of helplessness and want of control which was the chief characteristic of the learning stage can never be revived: the faculty of balance once acquired is a possession which he will carry to his grave. In this respect again it presents an exact parallel to swimming and skating.

One other interesting fact may be referred to as proving the close and intricate penetration of this acquired sense into the whole physical system. There is a very familiar class of dreams in which the circumstances in which the dreamer finds himself placed seem to render a speedy and prolonged flight from one object, or a similar pursuit of another desirable. Most dreamers in this case perform the imaginary flight or pursuit by the ordinary process of running, and when the dream assumes the less agreeable, but more sharply impressive form of "nightmare" we fancy either that our legs are in some way paralysed and refuse to move, or that they do indeed move or move in vain, beating the ground yet making no progress, like a squirrel on his wheel, and after an agony of frantic running we find that we have hardly moved at all from the spot at which we started. Now, it is a remarkable fact that in the case of those who have learnt to bicycle, and who ride with tolerable regularity, bicycling not unfrequently takes the

place of running in this class of dream, and the dreamer imagines that he has some form of a bicycle under him, the wheels of which, if the dream be a nightmare, from some mysterious cause decline to respond to the motive power applied to them, or else gyrate rapidly enough without, however, carrying the dreamer far or fast in the desired direction. This reference to dreams is here introduced in order to illustrate and emphasise the fact that the use of the bicycle and the balancing power implied in it become a kind of second nature, and to help us to realise how very intimate and subtle are the forms of muscular association established by it.

This, then, is the criticism which may be offered on that somewhat superficial view of the matter which was alluded to at the outset—the view, namely, that so far as bicycling may be considered an exercise at all, it is in effect an inferior kind of exercise, which only employs a very small and insignificant section of our muscular structure. Such an absorption of "a new sense" into our bodily organism, as the foregoing considerations would seem to indicate, entitles it to be regarded as an exercise which brings nearly the *whole* of the body into play, and not merely a portion of it; and it is observable that this feature of it is a constant quantity, present equally in gentle as in violent riding; it is, in fact, the normal accompaniment of every ride taken whatever the pace or distance. Bicycling, therefore, is undoubtedly a healthy pastime so far as it gives exercise to the body *in general* as distinguished from any special part of it.

But whilst the view that it is *only* partial and not general in its muscular operations is thus shown to be fallacious, it is undeniable that there are certain portions of the body which are more freely employed in it than others. These are so obvious that a mere allusion to them is quite sufficient for our purpose; they do not require to have that degree of attention drawn to them which it was necessary to solicit for those more recondite features of the case which have just been discussed. There is, indeed, a certain style

of riding in which it is only *too* obvious that nearly every prominent limb of the body is hard at work; the legs as has been before remarked, seem to be working up and down with the fierce regularity of pistons; the arms, though at one end (as is necessary in this style of riding) firmly riveted to the handle, are allowed every possible license of shoulder-shrugging at the other, whilst the trunk of the body sways to and fro as if it were an inverted pendulum or metronome, in which the head plays the part of the weight, and so traverses the maximum arc of its swing. To such a style of riding as this none would refuse the title of exercise, and, if not persisted in too long, it may no doubt be a very healthy form of it. The objections to it are, indeed, moral and æsthetic rather than hygienic. In the eyes of the conscientious mechanic it is unpardonable as violating the fundamental axioms of locomotive economy, whilst its irrepressible contravention of every canon of physical grace, not to say modesty, renders it odious in the eyes of Culture and Art. But even in the case of the skilled and cultivated rider, who knows that the weight of his body (which is indeed the main source of motive power) can be most effectively applied by minimising its motion, and by concentrating its operations in that portion of it, namely, the foot and ankle, which lies nearest to the point of application, there is no doubt plenty of local muscular activity required to enable him to maintain a fair pace along a smooth road; whilst the demands on such activity will be enormously or rather, one may say, indefinitely augmented by the various obstacles to be met with on the ride, such as rough surface, unfavourable gradient, and contrary wind. All these obstructions necessitate increased application of motive power, advancing sooner or later (according to the skill of the rider) to a stage in which a disturbance of the normal balance is involved. At this stage recourse is had to the arms, on which the duty is then thrown of constantly checking the inequality of weight by the application of force to the handle So exacting is this duty that if, after a ride of this description, the bicyclist

were asked to name that portion of the body in which he felt the severest aches, the more frequent reply would be, "in the arms," not "in the legs."

It is worth while to specialise another point in which the act of riding a bicycle may undoubtedly be made to contribute to important muscular development. Compared with our forefathers we are a degenerate race. We cannot even occupy a sitting posture without such support as they would have disdained. Chairs with shelving backs, not to say easy chairs, have long ago taken the place of forms or of those old chairs with carved straight backs—so straight that it was impossible to *lean* against them—which are the pride of Wardour Street. Now the bicyclist occupies a seat in which his back receives no external support whatever, although as he is engaged in active work, and not merely sitting still, it is clear that if any one might fairly claim the indulgence of such support, it would be he. Here again the experience and testimony of the learner may be called in to illustrate this point. He will tell us that long after he has mastered his balance, and has even advanced to the stage of taking a daily ride of moderate duration, he will still feel considerable fatigue in the loins and lower part of the back; and the eventual disappearance of these symptoms is entirely due to the fact that the necessities of the case have compelled him to develop new muscular forces about the loins and hips which thus enable him "to carry his back" without any further sense of its being a burden to him. Bicycling, therefore, may be recommended on the ground that it gives strength to the back as well as to the arms and legs.

The most prominent of the purely muscular advantages of bicycling have been here enumerated, and it would be difficult to find any other pastime in which such a *thoroughness* of bodily exercise is attainable. Indeed it is this very thoroughness, which, whilst making the pastime in this particular aspect of it so salutary, constitutes at the same time its most likely source of danger. It is comparatively easy in bicycling to reach the stage of fatigue without being

fully aware of it; there is a peculiar fascination in the exercise, a certain buoyancy and exhilaration produced by the motion itself, which diverts the attention of the rider from the fact that he is getting tired; whilst owing to this *thoroughness* of the muscular exertion employed in it the stages at which healthy fatigue becomes weariness, and weariness sinks into exhaustion, follow each other perhaps more rapidly than in most other exercises. On the other hand it ought not to be forgotten that in cycling each man can "cut his coat," so to speak, "according to his cloth." The cricketer is under an obligation to play the innings out; the oarsman if he be member of a crew must finish the course; the football player can hardly leave the field until the goal is won. The ordinary cyclist, however, is quite independent of all such considerations. He is always free to set himself a long or a short distance, to choose an easy or a difficult road, to ride with the wind or against, according to the precise amount of exercise that on any given day he may fairly require or feel healthily inclined for; nay more, should he find that he has overcalculated his wants or powers he can interpolate a dismount and a rest at his will and pleasure, or even curtail his course altogether. The danger of fatigue then is in no sense a *necessary* concomitant of the pastime; it is in fact always avoidable by the exercise of discretion and care, and the only duty that the advocates of cycling have to perform in this matter is to call attention to it as a possible risk, and to endeavour to impress on the cycling public the desirability of their employing an adequate degree of caution with regard to it. The mere development of cycling has of itself gone far to reduce this danger to a minimum. Ten years ago, when the possession of a bicycle and of the skill to use it was comparatively exceptional, every such possessor was naturally tempted to make the most of his distinctive position, and personal emulation was then to a great extent the ruling passion which dictated pace and distance. But matters are quite changed now; the glamour of novelty no longer surrounds the art, nor are

its votaries any longer the objects of special hero-worship. There are now thousands of cyclists who are well content to do just what their carefully and gradually developed cycling powers will enable them to do, and no more. These remarks, it is hoped, will not be interpreted as implying any indifference to the value of bicycle-racing, still less any disparagement of the efforts of those who, whether on road or path, have been continually expanding the area of its demonstrable possibilities. It should never be forgotten that it is to their perseverance and enterprise in this respect that each successive improvement in our cycles has most undoubtedly been due. These feats of constantly shifting "records" are the real advertising-column of the machine-makers ; the race-path, or the long distance course is the open market in which the manufacturers themselves compete, and the results of these constant trials furnish the test or gauge by which the ordinary cyclist is largely influenced in his purchases. It is difficult to see by what other means the comparative merits of mechanical skill could be brought into proper prominence, such prominence, that is, as would secure to the machinist a certain prospect of his ingenuity being recognised and rewarded, and thus serve as an adequate incentive to continually expanding flights of invention. Every cyclist, or would-be cyclist, is as such personally and directly interested in these exceptional exploits. All that is here intended is to imply that they are and ought to be exceptional, however praiseworthy, and that they need not enter directly into calculation in dealing with cycling in its more general aspect, and in estimating its merits as a healthy pastime for society at large.

We have hitherto been speaking of bicycling mainly. In the case of tricycling, the special feature of the balance of the body and the considerations arising from it do not enter so prominently into the question ; but in all other respects, as a muscular exercise, the two stand on much the same footing. In one respect, no doubt, tricycling might be thought to be the severer work of the two, for there is a

heavier weight to be propelled, and greater friction to contend against. On the other hand it is far easier for the tricyclist to husband and economise his strength. When his course is heavy, or if obstacles have to be surmounted, he can drive his machine as slowly as he likes and even bring it to a rest at any moment, while the bicyclist on the other hand must keep up a certain pace in order to maintain an equilibrium, and in mounting a hill, for instance, will often find it necessary to exert himself far more than the tricyclist, notwithstanding the greater weight the latter will have to deal with.*

Up to this point the precise nature of the exercise itself, and the muscular efforts implied in it, have alone been under consideration; but there are other points involved in the accompanying conditions of cycling which have a direct bearing on the question of its hygienic value. No

* Some such considerations as those above are obviously necessary to account for the fact that, notwithstanding these differences of weight and friction, the feats of long-distance riding recently performed on the tricycle do not fall so very far short of those performed on the bicycle, the maximum distances hitherto covered by 24 hours of riding on the high road being 222 miles on the former, against 260 on the latter. Regarded merely as an exercise bicycling possesses some most unquestionable points of superiority over tricycling. On account of the balancing required, the bicyclist has to employ his body in a far more thorough and complicated manner than the tricyclist; being seated farther away from the dust of the road he breathes a purer air; and the opportunities he gains for the development of "nerve" and "pluck" (see pp. 156–161) are far greater. On the other hand tricycling is undoubtedly attended with less personal risk; the rider can slacken up and rest at any moment without the trouble of dismounting, and the fatigue of remounting; and he can carry more luggage with him. These two latter points are of course of considerable practical importance in a tour. But it must be remembered that if any damage should occur to the more complicated machine it will be more difficult and costly to get it set right; that its conveyance, when not propelled by the rider (as in the case of a very steep hill), is a more troublesome business; that it is harder to steer; and, lastly, that stretches of road may often be found (particularly in the mending seasons) where only a narrow slip of ridable surface is left, which though sufficient for a bicycle, may not be wide enough to provide the double track required by the broader machine.

exercise can claim a really high rank in the list of beneficial pastimes, unless it be taken out of doors. In their purely muscular aspects, no doubt, many active amusements may fairly vie with or possibly surpass cycling; but few, if any, can approach it in excellence as a means of obtaining fresh air. The air which we breathe is, as all know, polluted and rendered unavailable for our further use by the very act of breathing it, and just in proportion as what is scientifically known as "diffusion" takes place will the air in which our exercise is performed be beneficial or the reverse. The exercises of the gymnasium are more exhausting than those of river, field, or road, because of the inferior conditions as regards "diffusion" of air under which they often have to be performed. In the ordinary view all air is good, which is not positively injurious; but this view is very shallow and imperfect. The question of air is anything but a purely negative one. There is an infinitude of hygienic distance between an air which is capable of bestowing the greatest amount of positive benefit, and one which only passes muster as innocuous. Even in the case of out-door exercises, it is impossible to maintain that they all stand on precisely the same level in this respect. Though none would question the beneficial character of any open air pursuit, still *relatively* it may be safely affirmed that on this point of purity of air, one is healthier than another, and that that form is absolutely the healthiest which *insures the most rapid passage* through it. Without wishing to lay undue stress on this point, or to seem to insist on an over-refined and unpractical application of theoretical niceties to a matter in which rough general principles are a sufficient guide, it may be pointed out that that special feeling of buoyancy and exhilaration which is so characteristic of horse-exercise and cycling is most probably due to their superior advantages in this particular respect. Where strong exercise is taken in close contiguity with others, as in the football melée, or even in a boat's crew, the condition of the air, influenced as it is not only by respiration, but also by the "waste of tissue,"

cannot possibly be as invigorating as that breathed by the cyclist in his isolated and rapid passage through it; and however much he may tax his physical powers in creating the motion, that very motion provides him with means of recuperation of an exceptionally effective kind. As an exercise, then, which can be taken under the most favourable conditions as regards purity of air, cycling must rank as high as any. A horse may indeed take his rider as rapidly through the air—for a very short distance even more rapidly—but the air breathed, though in an ordinary sense pure and fresh, is undoubtedly (owing to animal evaporation) *less* so than that inhaled by the cyclist, whilst the limit of distance for which such speed can be maintained is far more rapidly reached, and for anything over fifteen miles the cyclist will in most cases have the undoubted advantage in this respect over the equestrian.

But there is yet another point connected with this question of air. Air may be perfectly uncontaminated and fresh of its kind, and yet vary very considerably in its hygienic properties. The terms "bracing air," and "relaxing air" are household words with all of us, and "a change of air," is one of the most approved prescriptions of the family physician. Now, this is a remedy which the cyclist can more easily procure than any one. Such a "change" as is sufficient for most hygienic purposes can generally be obtained within a much smaller distance than is often imagined. A very slight alteration in levels, or in soils and geological formation, will often effect as great a contrast in the character of the air at 10 miles distance as at 100; and a day's quiet ramble on wheels in a district which it will only take the cyclist perhaps an hour to reach, and at the end of which he will have his own home comforts to return to, may often prove more efficacious as well as more economical than a week at a fashionable watering-place with all the troubles of the move and the possible discomforts and risks of a strange lodging. For those again who live in towns, or who have during the greater part of the day to breathe an air the ozone of which

rapidly exhausts itself in its purifying and antiseptic mission, the mere fact of being able to make the daily exercise the means of transport, if only for half an hour, into a more favourable region may make all the difference between health and sickness; such a preventive, if regularly applied, may be the means of averting many a break down and of enabling the daily struggle between the constitution and its unfavourable surroundings to be carried on with a fair measure of success. This class of advantage too can be almost indefinitely increased in the case of those who have the opportunity for it, by calling in the assistance of the railway, and thus creating a constantly shifting starting-point for the ride. There are very few parts of England in which, by occasionally taking the cycle a moderate distance by train, it would not be possible to have three or four rides a week and yet not pass over the same ground more than once in a quarter of a year.

There remains a further point about air in connection with cycling which must not be entirely overlooked. The air of the early morning is undoubtedly superior as regards its invigorating effects to that of any other portion of the day. This is generally understood to be due to the chemical action of vegetation under the first influences of the returning light of day; but whatever be the cause it is universally maintained that its effects are exceptionally reviving and salubrious. At the same time it may fairly be doubted whether in ordinary cases any very exhausting work, whether of brain or of muscle, can be beneficially undertaken before breakfast. Now cycling, as has been already pointed out, is not *necessarily* a violent or exhausting exercise, and if the cyclist be content to drive his wheel at a moderate pace he can very well get an hour's or even two hours' pleasant draught of morning air, passing through it at an average rate of eight or nine miles an hour, without any feeling of lassitude or a sense of having made too severe a demand on his unbreakfasted constitution. Short of actual walking, there is no exercise which is so *easily procurable* in the early morning as this. For cricket, lawn-tennis, and

such like games the morning grass is too heavy with dew, even if the necessary company of players could be got together at that hour. A morning row has to be taken in a morning mist, the fleecy curls of which as they float along the surface of lake or river are more picturesque than salubrious. For a ride on horseback, again, the rider is mainly dependent upon the early rising and punctuality of his groom. But the cyclist, on the other hand, is absolutely independent of every one and everything, save the weather, and he can start when and whither he will with no necessity for any previous arrangement of any kind. Even should he contemplate a somewhat longer and faster spin than can be judiciously taken upon an empty stomach, a mere crust of bread and a glass of milk placed ready for him overnight will be sufficient to ward off all feeling of faintness until the hour of substantial breakfast is due. Medical science assures us that the morning air is literally indeed and not merely figuratively "meat and drink," and it is itself capable of giving better sustenance to the body than many a breakfast hastily snatched by the late riser in his hurried transit from bed to business. An exercise which can be so easily employed as an encouragement to the formation of this habit of early rising, and which can provide the means of introducing a copious draught of morning air into the lungs at the cost of such very slight physical exertion deserves to stand extremely high in hygienic estimation.

The remarks hitherto made on the subject of cycling in its connection with health have dealt only with two aspects of it, its merits as an exercise of the muscular frame, and the beneficial character of the atmospheric conditions under which it can be taken; but these are not its only aspects. No exercise can be considered to be of a good representative type unless it can be shown to bear satisfactory relations to some of the higher factors of the human organisation. In our composite constitution mind and body react upon one another with such a nicety of associated influences that there is always a strong *à priori* presump-

tion against the success of any course or system in which either of them fail to secure a due measure of consideration. From a purely physical point of view it is quite conceivable that the treadmill may be a most admirable form of exercise ; but health is not solely a question of sinews, muscles, and lungs, and, apart from providing adequate employment for these, it is essential to a good pastime that it should not merely "pass" the time but should pass it pleasantly and briskly; a dull and monotonous exercise can never be a health-giving one. Games such as football, hockey, and lacrosse, the essence of which consists in constant individual competition, and in which each player is not only exerting himself but exerting himself with the direct view of individually achieving a definite object at the expense of his opponent, have a most important value in this respect. Each muscular movement is associated with a purpose and a desire which gives a stimulus and a zest to the whole operation ; there is always something to think about in it—something, too, which is ever shifting and changing with every varying phase and turn of the game. Nothing of this precise nature can be claimed for ordinary cycling, although of course the competition and excitement of a cycle *race* is very keen ; the interest of cycling is not so much inherent in the occupation itself: it is mainly derived from its surroundings. In this particular point indeed it resembles walking, but with this important difference, that the interest is multiplied by the excess of the pace at which it is performed. A walk, indeed, may often be a dull affair : the fixed natural objects passed during it may be too familiar to the walker, who from the comparatively limited area at his command has of necessity to traverse the same ground somewhat frequently ; or, again, the variable objects, such as passers by, may not present themselves in sufficiently rapid succession to relieve the monotony. But the cyclist with his far greater locomotive power need never find his ride dull. The longer range at his command provides him with a far less exhaustible variety of routes ; whilst the more rapid pace at which he moves proportionately multiplies the

number of living objects of interest which he passes in a given time, so that the mind is supplied with a constant succession of occasions for effortless and pleasant observation. These remarks are made in view of ordinary cycling only; in a tour, where the ground traversed is itself perfectly new, the stimulus to mental interest is of course greater still. But let us suppose the rather exceptional case of a cyclist who is making an extremely familiar round in which the living objects of interest present themselves at somewhat remote intervals. Even in such a case as this his mind will not be wholly unoccupied, for the management of the machine itself, especially if it be a bicycle, demands some amount of attention. Loose stones, ruts, and the thousand and one features which distinguish an ordinary highway from an asphalte path, will at any rate keep his attention sufficiently engaged to prevent the weariness arising from absolute vacuity. Besides, it may be remembered that there are a class of persons, such as students, teachers, authors, and the like for whose constantly occupied and possibly excitable brain some such intervals of comparative passivity and quiescence are in themselves a healthy change; for such as these an exercise which will make no exacting demands upon the brain, but will give it just enough of mechanical employment, as it were, to prevent its pursuing the track of it's own fancies, and reproducing the activities of the desk or lecture-room, will often be found invaluable.

There is yet another of the accompanying conditions of cycling, which is of sufficient importance to deserve mention. It would be a serious and mistaken limitation of the term "health," if we were to restrict its reference to those conditions of bodily function or organism only which are capable so to speak of precise physiological demonstration. There is such a continuity of relationship between the various parts and aspects which go to form that composite whole which we call the constitution of a man, that to confine ourselves to what would be generally understood as the purely physical side of the question, would be to give

it a very partial and inadequate treatment. Now, there is a certain constitutional habit or condition which is scarcely capable of exact scientific definition or analysis, but which is easily recognisable under the familiar title of "presence of mind." It is a condition which cycling, more especially bicycling, is admirably calculated to develope. The cyclist in dealing with the various possible obstructions to be met with in a ride is constantly being brought face to face with problems which demand instantaneous solution : not unfrequently the conditions of the problem are such that a wrong solution might be productive of disaster to his machine, or to himself, or possibly some other animate object : a risk, in fact, has to be encountered and surmounted, and what we call "nerve" is called into play. Now this power of "nerve" may no doubt vary very considerably as a natural gift in different individuals ; some persons are born with a greater degree of it in their temperament than others ; but over and above these innate variations, it is certain that it can be greatly strengthened and increased by education. Like muscular power itself it is to be developed by exercise. Every time that an occasion arises in which this promptitude of decision under sudden and exciting circumstances is demanded, and successfully supplied, the chances are increased, that the same result will follow on another occasion, and in proportion to the frequency with which such risks have to be encountered will be the formation and growth of this most distinct and valuable habit. It is often regarded as an inexplicable and somewhat foolish thing, that persons should voluntarily seek amusement in forms of pastime of which "risk" is an inevitable concomitant. But the fact is, such risks have a species of fascination for us, and it is well that it is so ; for Nature herself thus puts us in the way of acquiring habits and tendencies which are really indispensable in most cases to a safe and healthy life. So long as the natural conditions by which we are surrounded are what they are, it is impossible for us to secure ourselves entirely against the occurrence of circumstances in which our own well-being,

or that of others may depend entirely upon the courage and decision with which they are instantaneously faced. It is then by no means a piece of futile, or as some would say, culpable foolhardiness, if we allow ourselves occasionally to yield to such fascination, and deliberately set our faces towards pursuits in which a certain amount of risk forms a possible, if not probable, element. The mountaineer, when he returns after a month of *grandes courses* in the high Alps, not only brings back with him that renewed physical strength which glacier air and the actual exercise of climbing have imparted, but has also acquired that buoyancy of tone and courage of hope which is bred of dangers fearlessly met and skilfully overcome. There is indeed such a thing as culpable risk-running; it arises when risks are voluntarily courted under such conditions as would render a successful encounter with them obviously hopeless. The great majority of Alpine accidents have been due to a want of judgment as regards these conditions. Persons essay laborious and difficult expeditions who are either physically unequal to that kind of task to start with, or who entirely miscalculate their powers of endurance in it. The climb to the summit has exhausted them, and they have no reserve left with which to meet the far more hazardous operation of the descent, and when the difficulty comes upon them they are in such a state of collapse from fatigue that all promptitude of action is impossible; their whole system is unstrung and out of tune, and the necessary harmony between brain, nerve, and muscle ceases for the time to exist. But where due regard is paid to these conditions, few things are so bracing and invigorating to the whole constitution—mental, moral, and physical—as these moments of life in which the strongest forces of a man are revealed in one instantaneous effort, and in which mind, will, and muscle, combining with the most delicate accuracy of adjustment in a flash, as it were, of associated impulse, carry him successfully through the ordeal that faces him. Moments such as these are worth days of ordinary living; they are not only absorbed into the system and become a resultant

source of spontaneous and *unconscious* influence, but impressed as they are indelibly on the memory the recollection of them serves to give *conscious* confidence and encouragement, and to stimulate to stronger-hearted action in grappling with many a difficulty of ordinary social or professional life. It is obviously impossible to provide by any artificial means opportunities for thus calling these qualities into action. Their very essence consists in their arising unexpectedly; to create them of set purpose, to make them to order, so to speak, would at once rob them of all their virtue. We can only educate our "nerve" by indulging in pastimes in which such occasions are likely to arise naturally of themselves,—occasions, we mean, which without being of any such terrible character as to paralyse its action, and, as we say, "unnerve" us, should be sufficiently exciting to stir us up and force it into action. Bicycling, especially at the outset, is prolific of occasions such as these, and, a very long apprenticeship has to be served before they lose their potence, and that perfection of skill is reached in which the power of dealing with them becomes absolutely automatic. In the tentative stages of his career the bicyclist is constantly trying new ventures, and experimenting on various degrees of rougher surfaces, deeper ruts, steeper gradients (both up and down) and finer feats of steering: little or no time for deliberation is often given in such cases; promptitude of decision and what is commonly known as "pluck" are the requisites of the moment; there is an instantaneous call for the exercise of all the coolness and skill at command. The bicyclist has one great advantage in this particular branch of his education; he has an incentive to perseverance which is not often present in such cases. In most instances, to turn one's back upon a difficulty is not only a safe but an easy and comfortable process; but the bicyclist can only escape at the expense of a dismount, which though always possible is not always easy at a sudden juncture, and in any case it entails the penalty of re-mounting which is never welcome, and often (if the road be rough and wind strong) difficult or even im-

possible. In this way he carries with him his own whip and spur, so to speak, to stimulate him to his best and boldest efforts, and so long as his judgment does not convince him that a dismount is the *only possible* course open to him, depend upon it in the majority of cases it will be the last he will adopt. The experience of bicyclists will be found to be practically unanimous in this matter, and all will remember occasions upon which a discovery of some fresh resource of strength and skill has been as it were forced upon them, and they have thus been led to face and achieve a feat which at the moment had all the appearance to them of being extremely difficult, if not bordering on the impossible. Had it not been that the only other course was a dismount, they would very likely have shirked the test, and thus lost the chance of increasing their experience and confidence.

The spirit of enterprise and the readiness to face risks in matters of voluntary effort or amusement has been often commented on as a distinctive characteristic of our own youth as compared with that of other nations; it may be that we are unduly egotistical in making such a comparison, and that it involves perhaps a somewhat unfair disparagement of our neighbours; but there can be little doubt that it is owing to this habit of resolute and courageous decision in the face of difficulties that our place in the world as a nation is mainly due, and that games and exercises which in themselves tend to foster such a habit, furnish an important contribution to national as well as individual health. Not long ago the writer was being driven in a Hansom down St. Martin's Lane to Charing Cross between eleven and twelve o'clock in the day. It was a cold soppy day, and the street (which was then paved with granite) was as greasy and slippery as it well could be; the traffic, too, was unusually great, so great that an actual block had occurred, and the cab was stationary, waiting for it to clear. Just at that moment a bicyclist passed by, dexterously threading his way among carts, cabs, and omnibuses although they seemed to be so thickly jammed together

that not even a foot-passenger (one would have thought) would have ventured among them; the situation was positively bristling with risks on every side, and yet the cyclist pursued his tortuous course, and as far as eye could follow him, without mishap. Such an act is not in itself indeed one which can be commended; it would be worse than folly to advocate the use of bicycles in such exceptionally crowded thoroughfares as that; it argues too little consideration for the danger to which the bicyclist may expose others as well as himself; but that such a difficult and hazardous feat should have been attempted and successfully carried out gave evidence of a "presence of mind" and "nerve" such as possibly no other pastime could have developed to a like extent, and in spite of its inconsiderateness it could hardly fail to provoke admiration as typical of some of the most potent and valuable ingredients in the English character.

The attempt was made a few pages back to combat the popular notion that cycling gave exercise to the legs alone, and that like any other partial form of exercise it exposed its votaries to a disproportionate muscular development, or what is scientifically known as "muscular hypertrophy." In our own opinion such a view is delusive: at least, we cannot call to mind any case in a somewhat large circle of cycling friends in which such symptoms have displayed themselves. But to the mere suggestion of a layman in such matters no conclusive value is likely to be attached in the face of any settled opinion among members of the medical faculty to the contrary. It is not indeed clear whether any such opinion is widely entertained or not in the profession; but in any case it may be worth while to point out that even should this charge against cycling be regarded as fairly established the pursuit would of itself provide the necessary remedy. As a mere means of transport it at once constitutes itself a most convenient and valuable auxiliary to almost any other form of pastime in which the desired change and variety of muscular exercise may be sought. We may be living, for instance, four or five miles from a

river, and if we could only purchase the pleasure of a row at the expense of a good hour's walk each way we should probably be inclined to put the oarsman's pastime in the category of enjoyments which were entirely beyond our reach; but a cyclist riding his machine at an easy pace will be ready to take his seat in the boat in less than half that time, and will be nearly as fresh for the work as if he had just stepped across his garden to the river side. And what one cyclist can do, another can and will, so that in places where it would otherwise be impossible to get an "eight" or even a "four" together, a crew can be mustered with almost as little trouble as if the members were living in the same village or town, and within but a few minutes' walk of the water. And so again in the case of all other forms of amusement in which association is a necessity, such as football, cricket, lawn-tennis etc., *this enlargement of the area of combination* which is made possible by cycling must enormously multiply the chances and opportunities for introducing variety into the athletic dietary. The cyclist's muscles should never get stale or hypertrophied; if they do, it will be his own fault and not a necessary result of cycling itself. Again, in making his own special form of exercise ancillary to others, he increases its inherent value; for a ride *with an object*, especially a pleasant object, is a healthier because a more interesting business than a ride without one. On the way the mind is occupied with pleasurable anticipations of meeting friends, or calculations about the chances of the match; whilst enjoyable recollections of the scene in which he has just been taking part will accompany the cyclist on his return.

It is time, however, to touch upon some other objections that have been occasionally urged against cycling. One of those which obtained the earliest currency was that it is calculated to produce severe internal strains and hernia. Now it is beyond question that with a bicycle there is some risk of this in the case of those enthusiastic aspirants who are always adding inch to inch of their wheel-diameter, and who will not be contented until they possess a machine the

treadles of which it is just possible for them to keep their feet on and no more. On smooth level ground these adventurers will ride along glibly and easily enough; but when any real work is required of them, then the strain is more than they can fairly meet, the strength they put out is not *brought close enough* to its work, there are gaps in the continuity of muscular energy which have to be bridged over, and muscular jerk takes the place of steady muscular pressure. Under these circumstances it is quite possible that injurious results may be produced. Or, again, the act of springing into a saddle which is beyond fair reach may be an occasion, though not so likely a one, of a strain. But these dangers are incidental not to cycling, but to ill-advised and injudicious cycling; the average cyclist who is not the victim of such "vaulting ambition" runs no such risk. What was formerly the most fertile source of mischief, the habit oı straining the leg backwards for the step in dismounting, and sometimes from failure to get full hold of it suddenly slipping off it, has long since gone out of fashion; the only chance of any such strain occurring now is in the case of some real accident in which the bicycle is caused suddenly to fall over *sideways*—a somewhat rare occurrence—and the rider stretches his leg out towards the ground to break the fall. But exceptional incidents such as these are common to most pastimes; neither, considering the enormous "mileage" covered by the cycle in the course of the year, is the percentage of real accident anything noticeable: that percentage would have to be very largely increased before it reached a figure which would be worth taking into account when compared with the great and solid benefits which the pastime undoubtedly confers.

Another possible source of injury has been materially diminished by improved mechanical construction. The vibration which is sometimes created by the passage of the cycle over rough surfaces and which was formerly to a great extent communicated through the backbone and spring of the machine to the backbone of the rider has been sensibly diminished by the method recently adopted

of "suspending" or isolating the spring by means of indiarubber rings; by this attachment, and by the very abundant supply of vulcanised indiarubber to the tyres of the wheels vibration is now almost entirely cut off, and it is quite conceivable that further applications of the same principle may ultimately remove every trace of it. Still, for the present, in long rides, when the frame becomes so fatigued as to be abnormally sensitive to such jarring, it is undoubtedly well to bear this matter in mind, and to avoid riding at all *rapidly* over surfaces such as "granite crossings," on which the jolting will be proportionate to the rapidity of passage; and should the surface of the road be continuously lumpy for any long distance (as is often the case in the neighbourhood of large towns where the "macadam" gets honeycombed by the combined operation of the water carts and heavy traffic)—it would be well in extreme, cases to dismount occasionally and walk a little way, just to break the spell, as it were, of this disagreeable vibration. This should invariably be done if the rider feels fagged and jaded. When the body is in a fresh and vigorous condition there is a pliant elasticity about it which enables it of itself to resist the effects of this vibration; its own system of buffers and disconnecting springs is then in full and buoyant operation; but it is far otherwise during the last miles of a long ride, and a cyclist who may have ridden fifty miles without the slightest harm may expose himself to the chance of serious mischief in the next five unless he bears this important principle fully in mind. It need hardly be pointed out that the above caution has a special significance in the case of cyclists who have arrived at that period of life at which the machinery of the body has already begun to lose its elasticity from natural causes.

We have seen it urged as another objection to bicycling that it is confining to the chest, and has a tendency to create high or round shoulders. This is another case of a legitimate deduction, but from an illegitimate premiss. The premiss is simply the bad habits of ignorant and

ungainly riders. These habits are undoubtedly the exception, not the rule; but like a great many exceptions they obtain a far larger share of notice than is their due just because they are exceptions. When we see a bicyclist coming along in the style which has been previously described (p. 146) with the addition of having his stomach on the handle and his head well over the wheel, it makes more impression upon us than would be produced by the sight of a hundred ordinary riders, and we say to ourselves what an extremely uncomfortable as well as awkward attitude bicycling involves, and how it must contract the chest, curve the back, and congest the blood into the brain. But with those who have been taught to ride properly, nothing of this kind can occur. It is true that in struggling against a sudden gust of wind the bicyclist will sometimes find it necessary to "expose less sail," and to present his head instead of his full front to it, but this is only for an exceptional and temporary purpose; not even in mounting a hill will he adopt such a posture continuously, for he knows that any benefit to be derived by shifting his weight further forward will be more than neutralised by the disadvantage implied in the assumption of an attitude in which it is impossible for him to apply the weight and strength of his body to the wheel with anything like the same degree of efficiency.

As regards real accidents in cycling, they may be divided into two classes. There are accidents proper, such as cannot possibly be guarded against; and accidents which are either directly attributable to a want of experience or of thought on the rider's part, or which greater caution and skill might have modified or avoided. Accidents of the first class may occur with the cycle itself, such as the sudden fracture of some integral portion of it, due to some vibrating shock having "started" a hidden flaw in the steel. These are the most dangerous of all accidents, as they usually occur when the cyclist is going at full pace and without giving any premonitory warning: happily they are of very rare occurrence,—so rare indeed as

hardly to deserve consideration. Other mishaps with the cycle caused by the locking of wheels, the loosening of nuts or screws, and the displacement of tyres, though sometimes not unproductive of disaster, are generally preluded by symptoms fairly recognisable, and give the rider a sufficient interval to slacken up and possibly dismount before any serious result occurs. The majority of such accidents belong to the second class, as being preventible by a little anticipatory care. The cyclist should not only make himself a thorough master of the construction of his machine, but should cultivate the habit of doing with his own hand all such cleaning, oiling &c., as may necessitate the removal of any portion of it, or the loosening of any screws, so that he may have the best of evidence that everything has been properly fixed again. He should also from time to time carefully run hand and eye over *all* the different parts and fastenings of the cycle and satisfy himself of their secure condition. Special attention in this respect should be given to "appendages," such as lamps, bells, and bags: these, especially lamps attached to the hub of the wheel, may provoke serious mischief, unless the most scrupulous care is taken in their attachment. Habits of vigilant and systematic inspection such as these will go far to diminish the risk of accidents of this class, and it is to the credit rather than the disadvantage of the pastime that the formation of such habits should be entailed by it.

Most other accidents, in which the cyclist and his cycle alone are concerned, are the result of want of practice, and are only to be prevented by the acquisition of greater skill and experience: they are, as it were, the necessary weaknesses of childhood, and can only be grown out of. Two of the most obvious are "slipping the treadle," and a want of proper management of brake power in descending a hill. In connection with these a word or two of caution may perhaps be useful even for the practised rider as indicating sources of risk which are too seldom alluded to. If a cyclist dismounts in order to walk up a hill, it is not

unnatural for him to walk on the grass at the side of the road and wheel his machine in the channeling at the edge of it; should he do this, he will probably find that during his next mile or so of riding, first one foot and then the other will keep slipping from the treadle: the reason of this is that his smooth soles have been made as slippery as glass by contact with the grass. After a walk of this kind, or even after merely standing about on the turf, the cyclist should remember to scrape his feet well on some rough bit of road surface before remounting. The same thing is of course liable to occur, when the road on which he has been walking is wet and muddy, but for this case there is no remedy, and he must be careful until his soles are dry again, to maintain such a pace and position as would prevent any upset occurring even should he slip his treadle.

Another possible source of mishap is in descending a long hill, after or during a heavy shower, when the india-rubber tyre in time becomes so pliant and slippery that the brake loses its proper power over it. This will not often occur in England, but on the long Swiss hills, when the roads are streaming after a mountain storm, it may be found very troublesome, especially after a dismount, when the wet sole slips the treadle and deprives the rider of the supplementary assistance of back-pedalling. A prompt dismount on the very first symptom of such a condition of things is the only safe course; but the chances of its occurring may be diminished by the adoption of grooved tyres on which the brake seems to retain a longer and firmer hold.

With regard to the chances of accident from difficult road surfaces, and obstructions, such as droves of cattle, &c., it is impossible to give any formal advice; the cyclist's own experience in its application to the exact circumstances on hand must be the only rule. But in a general way moderate droves of cattle when straggling in column may be passed in safety, but if the drove be large and advancing in line, it is wise to dismount. A drover, however well-intentioned to the cyclist—which few of them

are—has practically very little control over the drove, and his efforts to clear the way often only increase the mischief. Sheep may be divided when *met* by shouting at them, but it is not safe to venture among them when *overtaken*. The movements of pigs have always defied human calculation, and if the cyclist likes to speculate on them he must be prepared for the worst. It may be well to warn those who may think of cycling on the continent in any pastoral districts such as Switzerland or the Black Forest, that cows and goats feeding by the wayside are often fettered by a cord to a stake, and that if the animal should be on the far side of the road from the stake, it is very hazardous to attempt to cross the string; also, that sheep and cows can never be *frightened out of the way;* they have been brought up as "members of the family," and consequently regard all human beings with an affectionate confidence which is apt to be embarrassing.*

Accidents but seldom occur in the present day from collision with other vehicles or with foot passengers. The cyclist may sometimes find himself in an awkward fix owing to the erratic conduct of a drunken driver, but the days have gone by in which deliberate attempts to drive a cyclist down can be made with impunity. The energetic action of the National Cyclists' Union and other similar associations has been sufficient to secure universal recognition of the proper rights of cyclists on the road. Still, occasional risks no doubt are run on badly kept roads, when through the ignorance of the passing driver the cyclist is forced on to stony or rutty portions of the road, on which it is impossible for him to ride with safety. This will continue to be inevitable until a knowledge of the real requirements of a cycle in such cases is more generally diffused: there are too many drivers who seem to imagine

* Cyclists intending to ride in Switzerland, and desirous of obtaining practical information on the subject, may be referred to a series of papers contributed by the writer to the 'London Bicycle Club Gazette,' in the year 1882. They can be consulted in the Library of the "National Cyclists' Union," 17, Ironmonger Lane, Cheapside, E.C.

that its thin slight wheels can traverse the same kind of surface as their own thick heavy ones, and who think it sufficient if they leave the cycle room to pass without any further thought of whether the surface of the room thus given is suitable or not for its passage. With regard to foot passengers the law requires the cyclist to give adequate warning of his approach, but it may be well to remind him that because he himself hears the sound of his own signal it does not always follow that they do, owing to their ears being deafened by some nearer or louder sound—as, for instance, where the road runs alongside a brawling river, or where some noisy vehicle happens to come rattling by at the time; in such cases the cyclist's bell is not so easily recognised as he may perhaps imagine and caution should therefore be used and a "wide berth" given. Special vigilance is required in the frequent case of children hanging on to the back of a cart, for these can neither see nor hear the cyclist approach, and are apt to drop off and rush across his track without a moment's warning. On the whole, however, when once a cyclist has acquired a certain degree of confidence and skill in the use of his machine, and is prepared to exercise an ordinary amount of prudence and common sense (especially as regards the pace at which he rides), the amount of mishap he will cause or come to is very small indeed; and even in the event of a spill in three cases out of four it will only be the machine that is damaged; the cyclist himself will come off unhurt. What injury may be received by him seldom exceeds a cut or bruise, or a sprained wrist. In the case of a wound, however slight, it is well to remember that contact with the road, or a dusty part of the machine, implies the introduction of dirt into it, and that the process of healing greatly depends upon the promptitude with which this is removed. The *very first possible opportunity* should be taken of thoroughly washing the wound, and of covering it from the air; if this has been done, the ride may be continued without harm; the warmth and circulation engendered by the exercise is beneficial rather than

detrimental. The writer was once bitten in the leg by a dog whilst on a long round, but after pumping on the bite for a quarter of an hour, and binding it up with a handkerchief he rode another thirty miles after it; and the rapidity with which the wound subsequently healed was very remarkable.

As in all other forms of exercise inducing perspiration it is essential in cycling that the rider should wear flannel. This should extend to the substitution of flannel for calico or linen even in waistcoat linings and trowser-bands and pockets, so as to avoid entirely the local chills to which the cold clamminess of wet calico will expose him; if braces or a belt be worn (neither are desirable in cycling) these should also be of flannel. A *warm* bath at the *end* of the day's work is better than a cold one; it is more cleansing to the skin, and soothing to the muscles; but a cold bath is better than none at all, and may always be taken with impunity provided the cyclist has not over-fatigued himself, or *allowed his body to cool down* after the exercise; in this case a dry rub should be substituted. A cyclist in ordinary health and of sound constitution, when only just a little tired, not exhausted, may safely take a plunge into the coldest water (no matter how hot he may be at the time) provided only he does not *stay long* in it; and it is wonderful how fresh and invigorated he will feel on remounting. Two, three, or even four such dips may be taken in the course of a long day's outing provided the above conditions be scrupulously observed; but it is essential that the water should be cold and fresh, and that the bath consist of just a plunge in, and a swim of twenty-five to thirty strokes and no more; to paddle about in weedy, stagnant and almost tepid water is the most debilitating process that can be resorted to under any circumstances.

A cyclist may take his exercise in all temperatures: he can always work hard enough to keep himself warm on the very coldest day, and the writer's experience has assured him that under a blazing continental sun, with the thermometer at 90° in the shade, it is possible to cycle even in the

hottest part of the day without discomfort; the rapidity with which the cyclist moves through the air creates of itself a pleasant breeze, and also prevents the full power of the sun from "settling on him," as it were, and making itself too severely felt. Under such conditions, however, it is desirable for him to remember that in any halts it is necessary to place the cycle in the shade; a machine left to bake in the heat of such a sun is liable to damage—especially in the tyres, the fastening of which may loosen in such a temperature and so cause subsequent mishap. In certain districts in hot weather, insect life is not only prolific but poisonous, and the cyclist may often get molested by horseflies of various kinds and wasps. A little ammonia applied *immediately* to the spot, and a resolute abstention from rubbing or scratching will prevent all further discomfort from the bite. In the case of wasps when blown on to the face of the rider and thus coming into forcible collision with him the sting will probably be found to be left behind, and should first be removed. Care must be taken to keep the pocket bottle of ammonia very securely stopped; the stopper, too, should be removed with caution, for in consequence of the heat and the jolting the ammonia is liable to spurt out with a burst and may injure the eyes if not held at proper distance.

With regard to diet, it is well to aim at reducing all eating and drinking during the ride to a *minimum*, and to defer anything like a solid meal to the close of the day. Whilst he is actually on his journey the cyclist should touch nothing until he feels *absolutely compelled*. There are many degrees of hunger and thirst which may be safely left unsatisfied without fear of exhaustion; and a little self-denial in this respect will establish a habit of abstinence which the cyclist, if on a tour, will find the greatest possible comfort to him. Drinking whilst there is still severe work to be done only tends to increased thirst soon after; a dip in a passing stream is a far better palliative. Wayside water in any highly cultivated districts, where the surface drainage is so largely contaminated with manures, is ex-

tremely hazardous, and ought never to be ventured on unless the purity of its source is unmistakable. As for alcoholic drinks, such stimulants are seldom, if ever, required where vigorous exercise is being taken under conditions in themselves so invigorating and stimulating, and if not required it is against all reason to take them. It should also be remembered, as against having any recourse to them on the journey, that the *immediate* effect of alcohol (especially when divorced from solid food) is most distinctly and undoubtedly adverse to *muscular* action. Milk is apt to produce discomfort when directly followed by severe exercise, but, if it be found absolutely necessary to take it, its tendency in this respect may be corrected by the addition of a *very few drops* of cognac—less than half a teaspoonful to a full tumbler of milk is ample; or a mixture of half milk and half water or soda water will need no such addition. On the whole the most salutary and thirst-quenching drink is some natural seltzer-water with the juice of a fresh lemon squeezed into it. But the happiest and soundest course of all for those who are engaged for any length of time in hard exercise is to try to acquire the habit of drinking nothing until the day's work is over. We would also add that a great deal of thirst may be prevented by keeping the mouth closed and only breathing through the nose. Smoking is so much a question of constitution and degree that it is useless to enter into it, but a cyclist who smokes in the saddle can only purchase that luxury at the price of extra thirst; it may also be added that what was said above of alcohol applies equally to nicotine, namely, that its *immediate* effects are prejudicial to muscular exertion. The experience of the writer who has tried both systems is in favour of entire abstinence from smoking for athletic purposes. One other practical hint in connection with this branch of the subject may be given for those who are making a cycling holiday: *never breakfast at the place where you slept.* Even on the continent, where hotel hours are far earlier than in England, it is impossible to obtain breakfast comfortably at such an hour as *ought*

to see the cyclist well on his road. The first morning hours (from five to eight in summer) are the golden hours of the day for all who would enjoy outdoor life; their influence on the physical frame is little short of magical, and the brightness and redolence of nature in its new-born purity seem to cling to you in recollection throughout the whole day, and to put you in tune with life after a manner essentially their own. Let the cyclist, then, pay his bill overnight, and take a glass of milk and a roll upstairs with him ready for the morning; this, with the help of the morning air and the observance of a moderate pace, will be amply sufficient to keep him going for three hours or more, at the end of which he will arrive at an inn where every one is up and ready to serve him, where the coffee-room is swept and garnished, and the kitchen-gear in full working order. Whilst his breakfast is being prepared, he can take his first bathe, or visit some object of interest, or read the morning paper; whereas if he attempted to breakfast before his start, he would most likely have wasted half-an-hour or more in waiting for it—for it is impossible to get such early orders punctually complied with even in the best hotels; he would also have subjected his temper to a severe strain in so doing (a very unfavourable beginning for a long day), and in any case he will have lost some of the spell and glory of the "top of the morning."

The cyclist's real difficulties lie not so much in the chance of accident, or in questions of diet, but as we have already hinted (see pp. 147, 148) in the temptation to outride his strength. There is no real cure for this, save in an appeal to his own good sense in the matter: still some helpful hints may be given. If the cyclist is out for a long day he should be careful to maintain a very moderate pace during the first two or three hours of it, and to dismount for any hill calculated to involve severe work. It is absurd to suppose that after eight or nine hours of sleep in which the muscular frame has been reposing in a state of gelatinous relaxation it can knit and set itself together again all at once; the process of solidifying will necessarily be a

gradual one, and any strain put upon the muscles before they are braced up and in the humour to respond to it, may prevent their assuming proper shape and consistence for the rest of the day. It is only too easy to sow the seeds of fatigue in the first hour or two of riding. Again, should the cyclist by sending his luggage in advance, or ordering his room or his dinner beforehand, tie himself down to arrive at a particular spot at a given hour, let him allow an exceedingly ample margin for halts and casualties when he is making out his programme of time and distance. Enforced hurry at the end of the journey is as likely to be prejudicial in respect of fatigue as undue haste at the beginning of it. In very many cases weariness is due not so much to the amount of energy expended, as to the very unfavourable conditions for muscular exertion induced by remaining too long in the saddle at a stretch. The weight of the body pressing down a particular set of muscles against the saddle is very apt to produce what the cyclist knows as "saddle cramp," a kind of deadness and numbness in the seat which robs those limbs which work from it as from a pivot of their proper spring and elasticity, thereby rendering the work they have to do unnecessarily burdensome to them. A full recognition of the supreme value of occasional dismounts is the best preventive of this cause of fatigue. The cyclist should remember that to walk up a hill is not only to husband his resources, but temporarily to bring a different set of muscles into operation, thereby giving the others a fresh start as it were and enabling them to resume their work with greater freedom. In this view to dismount *and walk* is far better than to dismount and *sit* on a bench or gate: the change of exercise induces a more real feeling of relief than the mere rest will give. Any natural excuse for a dismount on a long ride—such as a hill, or a bit of rough road, or the better enjoyment of a bit of fascinating scenery, or a tempting spot for a bathe—should therefore be welcomed and taken advantage of by the cyclist, with this reservation only that in the case of a bicycle the process of remounting

is with some in itself a fatiguing one, so that to be too often dismounting may eventually do more harm than good. A safe rule for ordinary cyclists is to walk up one hill for every two ridden up, and not to keep in the saddle for more than 9 miles at a stretch during the first and last eighteen miles of a ride, nor for more than twelve or at the outside fifteen miles during the intervening portion of it. But the degrees of cycling strength are infinitely variable, and general principles must always be more useful than definite prescription. One thing, however, is invariable, and that is the evidence of over-doing. If a cyclist on sitting down to his evening meal, finds his appetite vigorous and hearty, his sense of enjoyment of his food keen, and his method of taking it quiet, leisurely, and restrained, and if after his hard day's work and his hearty dinner he also sleeps soundly, he may rest assured that whatever may have been his sense of muscular fatigue on his final dismount, he has not done more than he was fairly fit for If, however, his appetite be at all impaired, or if he should find himself eating and drinking hurriedly and feverishly, and be conscious of a kind of nervous feeling that his dinner is not settling into him as comfortably as usual, or again if after he has got to bed, his muscles obstinately decline to "go to sleep," and his rest is disturbed with frequent cramp or tossings,—these are the infallible symptoms that he has that day ridden either farther, or faster, or more continuously than he should have done. He must take the warning seriously to heart: he should either take entire rest the next day, or confine himself to an extremely moderate ride indeed, and for the next five days let him reduce his intended work *by at least one third.* Very possibly the rest and the gradual seasoning may enable him to venture upon his original quantum at the end of the week in safety: but should any of the former symptoms recur, then let him be assured that (unless he is young and growing) he has already ascertained the full limit of the cycling powers with which nature has endowed him, and he must be prepared

thenceforward to mete out his distance, pace, and work accordingly.

But whilst thus plainly "taking up the parable" against this one prominent danger of excess, it is only fair to remember that the real charm of cycling lies not so much in itself as in what it enables you to combine with it, and that in this aspect of it no such risk of fatigue should be possible. The cyclist may get his 20 or 25 miles in the early morning, and ride on another 20 or 25 in the cool of the evening, whilst a whole world of possible pleasures of a quiet and unexhausting kind are at his command for the intervening hours. The botany, geology, or entomology of the district visited may be leisurely, nay, lazily if need be investigated: there may be objects of architectural, antiquarian, or historical interest for him to explore: he may spend the midday hours in fishing, sketching, or photographing; or he may choose some shady sequestered nook in glade or by river, and pass the time at his ease in reading some favourite book, or in quietly watching the ways and habits of squirrels, birds, or other animal life by which he may be surrounded. It is this thorough independence, this fertility of resource, this variety of combination, this gypsy-like freedom of open-air life and habit, together with the unlimited power of *graduating* the extent and force of the exercise itself, that makes cycling such an enchanting pastime, and so indescribably valuable to the health of those who indulge in it.

One more count in its praise may here be added, as being closely associated with what has just been written. It is an undeniable fact, that cycling is gradually giving rise to a new and more healthful view of holiday travel. The cyclist has discovered how far more interesting and enjoyable it is in visiting new countries or districts to frequent their bye-ways rather than their highways, and to study the life of the country in its normal and natural phase rather than in the more artificial garb it temporarily assumes in its "show" places. The quiet, leisurely independent way in which he can tour about is the very

opposite of the system of holiday travel hitherto so extensively adopted. Such tourists hurry themselves by train from one big town to another, or from one specially "starred" object of natural or historical interest to another. They crowd sight after sight into their memories with a rapidity which involves them all in an unprofitable jumble; and they map out their plans beforehand so as to compress the widest possible "circular tour" into the shortest possible time. Travel such as this may indeed be a change of occupation, but it is no holiday making in the real sense of the word. Let any one who is in the habit of touring on these principles make for once and away the experiment of noting down on each occasion in his pocket-book the amount of time which has actually been consumed, (1) in packing and unpacking, (2) in standing about in the waiting-rooms or luggage offices of railway stations, and (3) in sitting in the train or diligence; let him also reckon up the number of occasions on which scenes and places he may have wished and intended to visit have been forcibly ejected from the programme because the weather was bad, or some other obstacle intervened, and his previously mapped-out plan did not permit him to intercalate the delay; lastly, let him ask himself what he knows of the life and habits of the people of the country he has been to beyond those semi-anglicised types of them to be met with in the hotels or in the tribe of cicerones and voituriers attached to them. If such a system of calculation and inquiry were thoroughly and exactly applied, he would, we feel sure, be utterly surprised if not disgusted with the result. The cyclists' experience on the other hand is altogether different. He may or may not at the outset avail himself of the train for transport to a distant spot; but when once there, all correspondence between him and the ordinary tourist ceases. He has his own special mode of locomotion, and radiating out from some fixed centre he frequents what roads and visits what places he has a fancy for at his own time and pace; he has only to diverge but a little from the lines followed by the trunk railways or

diligence routes to find himself face to face with the genuine life of the people untarnished by foreign veneer; he becomes interested in their normal pursuits; he mixes freely with them in his wayside halts; every new object he passes he can stay and investigate at his leisure; his whole day is full of interest, and there is no occasion whatever for him to stint or curtail his enjoyment of it. In addition to the physical refreshment he has gained he takes back to England a rich store of definite and pleasant memories; he has throughout been really moving in a *foreign* land, and its various peculiarities have "soaked" into his mind in a perfectly gradual and natural manner. The typical tourist on the other hand, though he may indeed be able to enumerate a far lengthier list of towns, cathedrals, galleries, waterfalls, mountains, lakes and the like which have actually passed under his eyes, has probably failed from their very number to carry away any really clear or valuable picture of them; he has not been nearly so much under the restorative influences of the open air; he has on the other hand been continually exposing himself to all the wear and tear, the clatter and batter of an almost daily railway or diligence ride; he has wasted a large portion of his holiday in the disagreeable occupations incident to a constant change of hotel; and his chief recollections of the people he has seen will be confined to the various fugitive travelling-acquaintanceships he has made with his own countrymen: as for any foreign associations of a personal kind it is unlikely that he would be able to recall the face and figure of a single native of the countries he has visited who was not officially connected with its hotels or systems of locomotion. Now, against all this unrestful, unsatisfying, unrecreating mode of travel the newly-developed instincts and experience of the cyclist utter a healthy and emphatic protest. Cycling has started an entirely different view of things, which is rapidly influencing society beyond its actual cycling ranks. It is becoming fashionable now to find a charm and interest in the rural life and scenery of old England itself, and to

recognise that for a certain class of natural beauty, as well as for spots and objects of historical interest, our own land is without a rival.* Holiday-making after the style of William Black's delightful 'Strange Adventures of a Phaeton' is taking the place of the foreign railway rush, or if foreign parts be visited it is with a more decided view that the less ambitious the programme as regards distance and rapidity the more health-giving and really enjoyable will its realisation prove. Of this improvement in the general view, so beneficial and salutary in its promise, and so thoroughly in accordance with all sound hygienic principles, the recent enormous development of cycling has undoubtedly been a chief cause.

There is another advantage of cycling so obvious, that it would hardly call for mention were it not that it will naturally lead us on to allude to a further point of very considerable importance. It has been before observed that owing to the extent of ground he is able to cover in a ride, and the rapidity with which passing objects present themselves to his view, the cyclist will hardly ever find his exercise dull, nor feel the need of a companion in it. All the same, companionship undoubtedly lends a great additional charm to cycling, especially on a tour: it is so pleasant at the end of the day to be able to talk over the scenes and incidents of the ride, with one who has been an actual participator in them. Now, no pastime lends itself so readily and conveniently to companionship as cycling. Not even in walking can conversation be carried on with so little

* Even the merits of our much-abused English climate are also receiving juster recognition under the influence of cycling; for as an outdoor pursuit it is beginning to bring into prominence the fact that there are a far greater number of days and hours in the year during which it is possible to be taking open-air exercise without inconvenience from extremes of heat and cold in England than in any other country. For *still* out-door life, such as open-air Cafés, "Summer Theatres," and Concert gardens, no doubt our cooler evenings are unsuitable, and our continental neighbours have in this respect an advantage over us; but for most forms of athletic enjoyment (which are of greater hygienic importance) our climate is undoubtedly superior to theirs.

effort of voice, for the noise of the soft tyre of the cycle is as nothing when compared with the crunch of the pedestrian's boot. It has, too, this great advantage over walking—at least where two cycles and not a "Sociable" are used. The essential charm of companionship lies more in its being always *possible*, than its being necessarily and always *actual*. Now, the pedestrian can hardly part company with his fellow, neither on the other hand can the two (unless exceptionally tried and close friends) march side by side for any length of time in solemn silence. Under these circumstances, conversation ceases to be the spontaneous utterance of thoughts that naturally demand it, and the brain is driven to taxing itself to invent topics of talk to fill up the gap, a result which from every point of view is most undesirable. Nothing, however, is more natural or more customary than for the cyclist and his companion to ride at times in file instead of abreast, and whilst keeping within hail of each other, and thus retaining all the comforting consciousness of companionship to be nevertheless out of conversation range, though always ready to close up when there is really something to say. This advantage of companionship in cycling naturally leads us to the point to which we wished to call attention,—namely, that the invention of the tricycle has made it a pastime which can be shared by both sexes alike. It is impossible to overestimate the value of any out-door amusement, which proves itself both suitable and attractive to ladies. There is nothing whatever in the nature of the exercise itself to render the proportionate use of the tricycle less beneficial to the one sex than to the other; whereas the greater degree of confinement to the house to which ladies are necessarily subjected, and the more restricted number of out-door exercises which are open to them, render it all the more important that this recent addition to the list should receive full and general recognition. Two points only require special mention under this head. It is obviously undesirable that the weaker sex should be subjected to the nerve-testing risks, which attend the in-

experienced cyclist in his early ventures on the highway; it is necessary, therefore, that ample opportunities should be afforded for attaining adequate proficiency in private. A good deal may be done in this matter at those ladies' schools to which a fair-sized playground is attached, if only the recognised medical advisers would use their influence with the heads of such establishments to this end. Another material help might be afforded, if the owners of private parks throughout the country would sometimes kindly place their well-kept and little frequented carriage drives at the disposal of cyclists for this purpose. There are so many cases in which these drives are mostly out of sight of the owner's house, and in which no inconvenience or annoyance could possibly arise from admitting the learning cyclist of either sex to certain portions of them, at fixed hours in the day, that when once the desirability of encouraging cycling has been generally recognised, such a request, one would hope, would often be granted without hesitation. The second point demanding special mention is the one already so fully adverted to (pp. 173–176), but the urgency of which is all the more pronounced in the case we are now considering, viz.: the necessity for caution, as regards "overdoing it." So long indeed as cycling is a comparative novelty with ladies the medical faculty will inevitably have cases of over-fatigue brought under their notice, and anxious mothers will naturally protest against the introduction of what will then be regarded as a dangerous and baneful temptation. But let the experience of the past be our guide in this matter. The real and only remedy for this is to encourage lady-cycling, not to discourage it; so soon as it ceases to be exceptional, it will pass out of the ambitious stage, and will quietly settle down among the commonplaces of life. It will, we venture to think, be found impossible to stamp it out, and the sounder method therefore is to do everything we can to accelerate its maturity, and abridge its hazardous noviciate. Some victims will no doubt be sacrificed in the process, but the ultimate result as regards the national health will be cheaply purchased at the price. For the present it can

only be repeated that all that has been previously said about the causes and symptoms of over-fatigue and their prevention should be taken doubly to heart by the lady-cyclist. Further, reverting once more to the point from which we started, the subject, namely, of companionship in cycling—let it be understood that whatever be the sex of the riders, the recognised rule of such company-riding should always be that the weakest member of the party is to be the absolute arbiter of pace and distance—not indeed in his or her own person (for there will always be an anxiety to disprove this assumption of inferior strength), but that the responsible leader or organiser of the ride should always take the powers of the weakest as his standard of measurement.

We have thus far been considering those hygienic advantages which are *directly* involved in cycling; but there are other *indirect* advantages connected with it which from the extent and importance of their application have a still higher claim on our attention.

Let us first take the case of that very numerous class of lads and young men living in our large towns who are engaged at the work of the desk or the counter. It has hitherto been found extremely difficult to provide these with any form of suitable recreation after their day's work is over. Most of our ordinary English pastimes, such as rowing, football, and cricket (especially the last two) are almost entirely unattainable by them, because by the time they can reach their homes and get themselves ready for such exercise the necessary daylight is mostly wanting, even if river and ground be accessible; neither, again, as we have seen (page 154), are such pastimes feasible for them in the early morning. The consequence of this has been that being cut off from out-door amusements in the evening, and having no special inducements to rise early and therefore to go to bed early, this class has been hitherto almost entirely thrown back upon in-door evening recreations. Even where, as in the case of young men's clubs, these recreations are in themselves harmless and

from a mental point of view—and in the exceptional cases of gymnasiums from a muscular point of view—improving, the perpetuation of the same conditions of indoor air which have been present during the day—only with the questionable addition perhaps of gas and tobacco smoke—materially diminishes their physical value; whereas the inevitable hankering after the more festive and exciting attractions of the billiard-room and music-hall exposes the majority of this class to still more unfavourable hygienic influences. Without necessarily implying anything against the merits of the actual entertainments provided at such places, it should be noted that it is morally impossible for those who frequent them to avoid the concomitants of unnecessary "refreshments" and late hours. The possession of a cycle on the other hand will act favourably at either end of the day. The attraction of the morning ride, in its beneficent preparation for the confinement that is to follow, induces the substitution of early retirement for the visit to the club or music-hall; or, if the early rising be not yet in favour, the evening ride will help to clear the lungs of the impurities inhaled in shop or warehouse, and stir the stagnant blood into healthier and more vigorous circulation. To those interested in the development of the national health few sights are so encouraging as those of the asphalted streets of the City between the hours of seven and ten of an evening, when, freed from the traffic of business, they become for the time the public play-ground of the City youth, and their smooth surfaces are given up to roller-skates and cycles. There is many a lad now who rides his twenty or thirty miles in and out of these asphalted streets and alleys every night, who might otherwise be wasting his time and substance in the physically deleterious surroundings of the music-hall or public-house. The ease and rapidity with which he can glide over this even *unjointed* surface, so far superior in this respect to the jointed and therefore vibrating surface of wood pavement, has a charm for him which he seldom tires of, and if only he could be induced, as some have been,

to substitute for the evening ride or even add to it a spin over these silent streets in the clear bright air of the early morning, when our noble City, free of smoke, smiles in the pure radiance of the morning sun, and when, according to some enthusiasts, the perfume of new mown hay is to be inhaled even under the shadow of St. Paul's, he would be well on his way to the summit of hygienic perfection. It would be a great public advantage in this respect if on that fine wide open space of road on the Victoria Embankment this smooth surface could be substituted for the honey-combed and jolting macadam. A further step in this direction might well be taken in the admission of cyclists—certainly not tricyclists only—to the parks at fixed hours; or, better still, in providing for them special rings to which they might have free access at all hours. This no doubt will be done when the importance of cycling as a question of national health has met with adequate recognition. Horse exercise being an expensive luxury is an exercise for the "upper ten" only; the comparative cheapness of the cycle puts it within reach of the million. Speaking roughly the best bicycles even when perfectly new may be had for from £15 to £20—(tricycles cost half as much again)—and bicycles which are every bit as good as new, but which the introduction of some slight alteration or improvement has thrown upon the second-hand market, may be had for from £7 to £10, or even less. So far as it can be affected by ordinary use, the body of a cycle, being of steel, is practically imperishable; a very occasional renewal of paint, rubbers, screws, or bearings, is all that is required to maintain it in its original perfect condition. Barring accidents a sum of from forty to fifty shillings for every five years ought to suffice for this, whilst five shillings a year is more than sufficient to provide all that may be required in the way of oil and cleaning things. Allowing another £1 a year for repairs due to accident, it will be seen that an ordinary cyclist can keep his machine for less than thirty-five shillings a year, a sum which will barely

see a horse housed, fed, and groomed for a fortnight, to say nothing of the difference in the original cost of the two and in the duration of their serviceable life. If we only make a calculation for a period of twenty years, a somewhat high estimate for the working life of the horse, and assume £50 as its price, and £50 as its annual cost, it will be seen that for the one person who at the price of a thousand guineas can keep a horse, at least twenty can keep a cycle. Unquestionably therefore cyclists have as strong a claim on the national purse in its provision of public recreation-ground as the owners of horses and carriages, and it will be impossible in the face of facts such as these to dispute that claim much longer. If this country were unfortunately to be forced into a European war at the end as at the beginning of this century, and commerce were consequently suspended, from what class of young men, it may well be asked, are our fighting ranks more likely to be recruited than from those whose profession would by the very circumstance of war be crippled if not suppressed? Happily for us there never was a time at which the average athletic condition of the young men of the commercial class was so satisfactory. What with evening rifle drill and morning cycling there is a physical and moral tone about them vastly superior to that of their predecessors, and a comparatively short period of military training would convert them into some of the finest troops the world has ever seen. It would surely then be a matter of prudent economy as well as of administrative justice for the State to devote some portion of the care and expense bestowed upon its public parks to the direct encouragement of this class of athleticism. A few thousand pounds spent upon the construction of cycling tracks on national ground in the heart and on the outskirts of the metropolis would be amply repaid by the results. If it be objected that the owners of horses and carriages make special contribution *as such* to the State funds, whereas the cyclist *quâ cyclist* does not, it may be pointed out in reply, *first*, that the wear and tear of road surface created by the rubber-tyres

of cyclists is infinitesimal as compared with that caused by horse and carriage exercise—it is, in fact, less than that created by walking: and *second*, that the contention would equally exclude pedestrians from the parks, who *as such* contribute nothing whatever to their maintenance. In any case should the point be seriously insisted on, it would be easy to adjust the balance by fixing some trifling toll to be paid by those cyclists who frequented the tracks.*

We have thus endeavoured to point out the importance of cycling in connection with our commercial classes, but its indirect advantages penetrate even deeper than this into our national life. If there is any one question which is just now uppermost in the mind of the thoughtful and observant citizen, it is that sad problem which the centralising tendency of modern civilisation has created, and the solution of which is, at the present moment, the subject of so much anxious debate. This centralising tendency has no doubt been temporarily accentuated by an almost unparalleled series of "bad seasons," which, coinciding with sudden and very possibly exceptional outbursts of fertility in other parts of the globe, have tended for the time to the

* Whether cycling in general should be made to contribute to the revenues of the State is an entirely separate question, and one which it is not altogether easy to answer. We venture to think as a matter of principle, that the development of cycling will ultimately prove of such great value to the State, that to check it by a tax in any form would only be killing the goose with the golden eggs. In any case we have no hesitation in saying that the most injurious form which such a tax could take, would be that of an "annual licence" to keep or ride a cycle. This would cut at the root of all its influence as a "decentraliser" (see pp. 187–189). Some form of "plate" or "badge," which the manufacturers could obtain from the Government, and rivet into the flange or hub, or some other endurable portion of the machine, would, in our opinion, be the least objectionable form which a "cycle duty" could assume. It would save the necessity for any troublesome system of workshop inspection, such as manufacturers might fairly resent, and the incidence of the tax would fall most heavily on the first, and presumably the wealthiest purchaser of the machine, being less and less felt as the cycle sank through the different levels of the second-hand market, until, by the time it reached the labouring classes it would have ceased to be appreciable.

depression of home agriculture ; whilst the recent development of our system of national education has made the rural youth all the more eager to quit a home where the prospects are for the moment so discouraging, and to try his fortune in the more active and intelligent centres of town life. How to spread out the confused heap of our urban population over a wider area ; how to make the current of the national blood now plethorically congesting, as it were, in certain selected spots circulate more evenly and freely through the country ; how to decentralise, in fact—this is the momentous question of the day, and on it cycling has undoubtedly a great deal of light to throw. If we could imagine for a moment that the human race were endowed with wings, should we expect the working man to prefer a room in a fetid alley to a cottage in a garden from which a short hour's flying would land him at his work? Or would those whom the pleasures and varieties of congregated life attract from their duller, because more lonely country homes be so ready to forsake them if they could thus readily transport themselves at any moment and at no cost whatever into their coveted haunts of town excitement? What again is the reason that our manufacturers and merchants raise the tallest possible factories and warehouses on the smallest possible base, in sites only to be purchased for a fabulous sum? Is it anything else than their wish that their goods should be at the heart, and they themselves, so to speak, in the ear of the world's market? Whatever then tends to facilitate communication, locomotion, and transport must have a direct value as a curative for this terrible disease of modern life. The telephone, the telegraph, the railroad, the tramcar—it is to these and such-like agencies that we must look for the real solvents of this social incrustation—they must furnish the main salve for this social sore. Whatever will help to make one spot as good as another with respect to the ordinary inter-communications of life, will of itself help to decentralise us, and to expand the area over which the necessary energies of modern civilisation can be made to

operate without material let or hindrance. Allowing for stoppages and the often circuitous course of the railway route, a working man may reach his town work from the same suburban or even rural distance quite as rapidly on a cycle as in a train; whilst as ordinary roads are and ever will be more numerous than railroads, and are accessible at every point of their course, and not merely at stations, the use of the former opens out to him a far wider choice of locality for his dwelling. For a lodging in the thickly built hamlets that cluster round our suburban railway stations a higher rent will be demanded than he would have to pay for a far more salubrious and pleasant home on a bye-road at a distance from the line; a cycle, therefore, will be the means not only of adding to his own and his children's health, but also of increasing his weekly savings. True the machine itself will cost something to start with, but owing to the rapidity with which fashions alter, the price at which a really serviceable albeit superseded type of cycle may be obtained is now exceedingly small (£4 or £5 only), a sum which, supposing him to be otherwise living at a distance of six train miles from his work he would have spent in six months of railway journeys, so that at the end of half-a-year his possession will become a source of daily gain to him. A workman on a cycle with his tool-bag slung over his back or pendant from the handle is already no uncommon sight: the functions of the cycle as a decentraliser are already in incipient operation.

Again, as materially lessening the disadvantages of rural life, and providing the means of relieving its monotony, cycling will help to check those centripetal forces which have recently shown such strength. By means of the cycle the lads of neighbouring villages can be brought more easily together, and can combine more freely for recreative and other purposes; "society" becomes possible even in our rural solitudes; readier access, too, can be obtained to the nearest town for occasional sights and amusements; the village ale-house will rapidly cease to be the one attractive thought on which rustic minds dwell whilst

rustic hands are plying the spade or speeding the plough. All this will tend to brighten the lot of the agricultural labourer, and to induce a more restful and contented spirit with regard to it. This increased facility of communication, moreover, bids fair to exercise an important influence in the propagation of the race. Shut off for the most part as they hitherto have been from all society save that of their own village, our agricultural families have naturally been driven to inter-marrying, until it has become no uncommon thing to find in a small village one-third, perhaps, of the inhabitants bearing the same name, and in walking round a country churchyard the visitor cannot fail to be impressed with the small number of different names to be found on the tombstones. For this in-and-in breeding with its deteriorating consequences, cycling promises to furnish a remedy, and several instances have already come under the writer's notice in which courtship has thus been carried on by farm labourers at very considerable distances from their homes. The increased use of cycles again by the higher classes, is itself helping in its way to infuse passing life into our little village towns, and the landlord of the country inn has now no better friend or customer than the cyclist. All this is exceedingly hopeful and encouraging, as helping forward the urgent and imperative task of national decentralisation.

Cycling, moreover, has something to say with regard to the very important question of agricultural economy and land cultivation, inasmuch as it is serviceable not only for personal locomotion, but also for transport of goods. Market produce has in most cases to be taken to the nearest railway station, and thence transferred by train to the nearest market centre. Unless the station happens to be on the direct line between farm and market, it is obvious that extra distance has to be traversed in this way, to say nothing of the probable loss of time involved in the change from cart to luggage van. Very likely the distance may be too great for direct transport by horse and cart, and even if it were not so, the amount or value of the produce to be sold may not be sufficient to make it worth while to

incur the expense of any such form of transport. In this case the produce being perishable is lost to the community: the new form of "carrier-tricycle," however, will save it. Some such economy of transport for the smaller and more perishable forms of land produce will be essential to the success of any effort to introduce that system of small independent holdings, which according to our best authorities is supposed to be the most efficient and satisfactory method of securing that English soil should receive the highest cultivation of which it is capable.* Cheap food, especially cheap vegetable food, is an important item in the programme of national health, and to this again cycling is found capable of contributing.

Interested then as we undoubtedly should be as a nation in an invention which has so many direct bearings on our national health and prosperity, it is fitting that we should consider in conclusion whether anything special can and ought to be done to assist its development and application. It has been already suggested (p. 185) that in the metropolitan districts cycle-tracks should be laid down in the parks, and the same suggestion may be offered as regards the parks of our larger provincial towns; for the smaller towns where access to the country roads can be more easily obtained there is no such necessity. But what is most urgently needed on all hands, especially if cycles are to be of any use to agriculture, is the improvement of our country roads. The abolition of the turnpike-trusts and the glaring inequalities in the burden of road-maintenance now cast upon the different parishes, have resulted in many instances in the most rapid and disastrous deterioration. It is useless to expect that any satisfactory remedy for this will be devised until County Government (another factor

* In foreign countries, where such systems of small tenure are in operation, the class of produce here referred to is often conveyed to the nearest market by dog-carriages—a practice which our legislature has wisely and humanely prohibited. The *utility* of cycling, apart from the healthiness of it, is not, of course, confined to the above instances, as witness the "newspaper" tricycles in London, the substitution of a cycling for a walking post in rural districts, and its prevalent use by our country parsons and doctors when on their professional rounds.

of decentralisation) is thoroughly established, and local authority has eyes to see how large an influence the condition of the roads must have on local prosperity, and what a much wiser and more economical use of money it would be in many a rural district to spend it on ordinary road-making rather than on the far more expensive, restricted, and possibly unremunerative form of the railroad. When the day has come in which every county shall be found to vie with its neighbour in competing for the honour of having the best roads in England, and when every district road-surveyor shall be compelled to perform his rounds on a bicycle, then, but not till then, shall we be in a position to affirm that the full possibilities of cycling have been realised.

We have seen that the spread of cycling among our working classes—both agricultural and artizan—is of undoubted hygienic and economic importance; but small as is the cost of a cycle when compared with its real practical value, it nevertheless is a sufficiently large sum to form a serious obstacle in the case. To meet this difficulty we venture to think that some such system as that on which local "clothing clubs" or "coal clubs" are worked might advantageously be brought into play. Workmen need to be encouraged to make small weekly payments for such a purpose, and when (say) half the sum required has been contributed, they should be allowed the use of the cycle, which should remain the legal possession of the club until the full amount of weekly payments has been made. Immediate advances might similarly be made for repairs in any case of accidents (the weekly payments being resumed to meet them), and the club should keep a spare cycle or two to be lent during their execution.

We are also inclined to think that the time is not far distant when some acquaintance with cycles, both as regards use and construction, might fairly form part of the practical *curriculum* for both sexes at our Board Schools. In the meantime it would be a material help to the spread of useful information on the subject, if some central cycle museum could be established in London in which a specimen of every new form of cycle of any importance, together

with all appliances and inventions connected with it, should be deposited and remain on view, and in which explanatory lectures should be delivered, and every opportunity given for those interested to dissect and (under proper direction) reset the machines *with their own hands*, and thus to acquire a thorough practical knowledge of all known varieties of them. Considering how important an influence cycling has upon the health and usefulness of those whose labours are the mainstay of City commerce, some such institution as this might perhaps form a not inappropriate branch of the City Guilds Institute for the advancement of Technical Education.

One other suggestion we would offer to Railway Companies. Their charges for the conveyance of cycles for long distances are extremely reasonable, but for a short distance some lesser fare than the present *minimum* shilling would be a great boon to the cyclist. His greatest need of railway assistance is to help him to get quickly out of his town to some country spot, and thus enable him to avoid the necessity of always traversing the first four or five miles of road, which may be wearisome to him from their familiarity, and which in any case are pretty certain to be lumpy and out of condition from the heavy traffic. It is obvious that if the company's officials had to be *constantly* putting cycles in and out of the luggage van, much delay and inconvenience would be caused; but we venture to think that there might be one or two trains in the day, particularly on Saturdays, by which cycles might be taken, and special provision made for them (as in the parallel case of "hunting trains"), and that for their conveyance by these trains there should be a minimum charge of sixpence or even less. We feel sure that the companies would not be losers by such an arrangement.

With these hints for the assistance and development of cycling we take leave of the subject.

DRESS,

AND ITS

RELATION TO HEALTH AND CLIMATE.

BY

E. W. GODWIN, F.S.A.

INDEX OF ILLUSTRATIONS.

[*Where only approximate dates can be given, the letter* c *is prefixed.*]

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The author desires to acknowledge the valuable assistance he has received from Miss Bonomi, to whom he is indebted for preparing all the drawings in illustration of the 16th, 17th, 18th, and 19th centuries.

DRESS,

AND ITS

RELATION TO HEALTH AND CLIMATE

AS Architecture is the art and science of building, so Dress is the art and science of clothing. To construct and decorate a covering for the human body that shall be beautiful and healthy is as important as to build a shelter for it when so covered that shall be also both beautiful and healthy. Where art is a living reality with peoples, their costumes will be the first to declare it; and quite the surest sign of the hollowness of modern art-pretensions is, that our dress remains a limbeck not reflecting anything, be our homes fashioned like the architecture of the time of Sophocles or Virgil, of Beowulf or Chaucer, of Shakspere or Goldsmith.

Hamlet when the wind was in the south knew "a hawk from a handsaw" because, as he puts it, he was "but mad north-north-west." Our joy in the beautiful, our longing for health, depend, I fear, too much on the way of the wind. To commit beauty—because we cannot help it; to make for the healthy—as a matter of course; to breathe in an atmosphere where the sunbeam throbs with art, and the rain is woven with sanitation, are, perhaps, possible only in the land of Utopia. We might, however, make for that land, and near it, if we were more in earnest, more thorough; not by way of frowns and long faces, but by that old Japanesy method of taking delight in all that contributes to beauty and health.

Beauty and health :—Certainly ; for they are not incompatible, as really we might be excused for supposing if our experience had been confined within the walls of certain sanitary Exhibitions. No doubt art and science might be on a more distinctly sympathetic footing than they have been, they might take more delight in one another's work. The scientifically-minded is too apt to look on art with a sort of pitying smile, as if it were something to play with ; while the artistically-minded, though perhaps more sensitive and sympathetic, is still too often disposed to view *his* ideal as *the* ideal, and refuse to profit by the offices science might and, I venture to say, would gladly render him. Science and art must walk hand in hand if life is to be worth living. Beauty without health is incomplete. Health, can never be perfect for you so long as your eye is troubled with ugliness. Of a surety there comes a time when custom breeds a habit ; your eye ceases to be troubled with ugliness ; you walk down Baker Street or Gower Street as happily as you would down the High Street at Oxford. Doubtless, too, there comes a time to some folk when they can travel by boat from London Bridge to Gravesend without any sense being in any degree affected. And there are unquestionably those who, in spite of Lorenzo's denunciation, are " not moved with concord of sweet sounds." With these more or less dead organizations, these brains whose avenues are partly closed, we cannot hope to do much. Our business is with people who know a hawk from a handsaw or a heron, whichever way the wind blows.

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The history of dress is curiously parallel with that of architecture ; indeed, we might almost say that to dress rightly, and build rightly, and speak rightly, are the three great primary arts. As speaking involves poetry and music, as architecture involves painting and sculpture, so dressing involves in principle all these. To dress well you must possess the gift of colour, and be a master of form. But this is not enough ; with these accomplishments you might clothe a dummy or a corpse satisfactorily, but not a living

human being; for there comes into the problem with this word *living* the element of motion. I do not mean the mere action of moving the limbs; but the action of breathing, of growth, and of decay. And it is here that the laws of hygiene must be faced. We may obey them or disobey; but in the measure of our obedience or disobedience will be the measure of our health or no-health. To build architecturally we must have not merely proper materials, and sound construction, and pleasant balancing of light and shade; but the ornament should be good in itself and well-adjusted, while the heating and ventilation, among other sanitary items, should be carefully considered. To build a dress or costume demands just the same kind of thought; and where the heating and ventilation are neglected we may be quite sure that we shall suffer. This little handbook is not written as an attack on tight-lacing, nor does the high-heel boot trouble me over-much; these are but two details of a style which is fundamentally and radically bad, a style which will prevail so long as the milliner's dummy is accepted as the ideal human form. Nor have I couched my pen to run a tilt against the chimney-pot hat, and dreary mixtures of black and grey; for these are but parts of a system founded on a pretentious, puritanical purpose—a declaration of faith in ugliness with the collateral intention of subjecting the body to a mild sort of torture.

Before tracing the history of the dress of civilized nations, and the effect on costume of climate and material, we will briefly glance at the broad distinctions to be traced, and then take a look at the attempts made by savages to put themselves in some kind of apparel.

We observe first, that the dress of civilized nations may be broadly divided into two great classes, the LOOSE and the TIGHT. That this primary distinction is owing to climate there can be little doubt, for the loose arrangement is, and ever has been, the favoured method in warm climates, while in cold climates the tightly-fitting mode has prevailed. The highest type of the first class is seen in the Greek chiton (*χιτών*) and himation (*ἱμάτιον*), as represented

in sculpture and on vases, of 450–350 B.C. The highest type of the second is found in the effigies and paintings of England and France about 1350 A.D. Special materials have, however, modified this general rule: thus, the very thin gauzes of the East, the finer silks, and indeed the more delicate fabrics generally, may be found used in hot countries after a more or less tightly-fitting fashion. Of this perhaps the most marked instance is the gauze bodice worn by certain Indian ladies to this day, and which in many cases is sewn on the body, so as to fit it like a skin. Again, it should be remembered that a dress loose in the principle of its design, may become tight in practice from scantiness of material, necessitated either by a rise in the market prices, or by the impecuniosity or economy of the wearer. Indeed, as you pursue the study of costume, it will not always be easy to draw a hard and fast line between nations and styles, for the loose and the tight systems mingle and overlap one another; the fashion of the South is borrowed by the North, and the East is reflected in the West. The result has been sometimes successful; but it is to some of the attempts made to assimilate styles, which have been developed under natural and artificial conditions widely different from ours, that we owe much of that unreasonableness which infects modern attire. Nor let it be supposed that this unreasonableness is the product of our time. Our originality and invention in the matter of dress is, like the originality of our architecture, mostly copied; and the unfortunate thing about both is that the copyist has rarely considered whether the conditions or surroundings of the copy are as those of the thing copied.

The origin of dress is no doubt traceable to the desire to distinguish or decorate certain individuals. A feather inserted in a hole each side of the mouth as worn by a tribe in South America, affords us an example of early finery, which, like the skin decoration of painting and tattooing, cannot possibly have arisen from any sense of decency nor from any want of protection. To find savages living in a state of simple, unaffected, unornamented nudity is rare, and I

believe they have been found only in the tropical primeval forests of South America and in Central Australia. Feathers, flowers, or applied ornaments of some kind, seem to be almost a necessity to savages. To leave nature alone would appear to be impossible to them, for if they cannot add to it they will alter it; cutting their teeth into patterns, as in Africa, shaving their heads, compressing the form of infancy in some particular direction, and generally exaggerating special features, as low-down, brutal, or vulgar minds are prone to do.

The earliest clothing, as distinguished from ornament, was made either of the leaves or bark of trees, or the skins of beasts. We may still see the "leaf-wearers" in India; for at a yearly festival in Madras the low-caste people put off their usual attire, and assume the Adamite apron. In the Brazilian forests grows the *lecythis* or "shirt-tree," and the rude native rolls off the bark of it in short lengths, soaks it, beats it so as to be pliable, cuts two slits for armholes, and slips it on. To clothe yourself in the skin of a wild beast is a very easy toilette, and the savage soon learned how to dress the skin by rubbing in fat, and suppling it with his hands. So far the savage applied his clothing much as nature gave it him; but the native of the South Sea Islands went further, and *manufactured* the grass into garments, by simply plaiting it. Here at last is the discovery, the original thought, the invention from which proceeds all the textiles of the earth—for weaving is after all nothing more than plaiting of hair, wool, silk, flax, cotton—animal and vegetable fibres, which were spun by aboriginal man with laborious twisting by the fingers, long before the introduction of the first spinning apparatus of spindle and distaff and whorl represented on the earliest Egyptian monuments.

* * * * *

This word EGYPTIAN at once introduces us to civilization. When man began to build he began to dress; and as the beginning of building was nearly as rude and natural as a beaver's hut, so the dawn of dress was but the

shaping or draping in a very rude manner the skin of the wild beast or the plaited grass. Between these and the first linen garment of which we have any record there must have been a long period of years concerning which we know absolutely nothing. We have, indeed, little to guide us until the time of the 4th dynasty (over 2000 B.C.). At that time, however, the city of Memphis was established, the Pyramids were being built, and the kingdom of Assyria was on the eve of being founded. It would be the merest speculation for us to attempt to gather any idea of the forms and materials of the costume of the mother country in Central Asia whence Hindoo and Egyptian proceeded. We are compelled, therefore, to start our history of dress at a time when Egypt had become a highly civilized nation.

Egyptian, and, indeed, all costumes of old civilizations, do not appear to have been affected by that spirit of change which has dominated European dress since the close of the thirteenth century. Broadly speaking, the costumes we see figured on Theban monuments, at Beni-Hassan, and in Papyrus rolls, may be divided into three classes: (1) the royal, in which are included gods and priests; (2) the upper class, and (3) the working class. The labouring population used woollen fabrics, and the working man had simply a loin-cloth and a girdle. At his work he often wore nothing but the girdle. Fishermen, boatmen, male dancers and wrestlers are thus pictured. The women of the lower orders wore sometimes only a skirt, tied close under the breasts, and reaching to the ankles; or a loose tunic to ankles, fastened with strings at the neck; and over this those who could afford it wore for holiday attire a transparent linen skirt or petticoat, secured at the waist with a girdle, their wigs being made of wool in imitation of the hair-wig. The working-man's child went about naked, and the infants were, happily, not familiar with swaddling clothes. On the other hand the children of the upper classes were duodecimal editions of their elders, as is still to be seen in Japan. The ladies of Egypt wore mostly linen, sometimes cotton. The under-garment was a skirt

or petticoat, often richly coloured in woven or embroidered pattern, secured at the waist by a coloured sash, or *suspended by straps over the shoulders.* I emphasise these last words, as shewing that the Egyptians were quite familiar with the hygienic system we are now anxious to see adopted, of suspending the weight of our apparel from the shoulder. Over this long skirt was worn a large loose robe or chiton of the finest linen, having what appear like loose sleeves, but which I think an examination of the monuments will prove to be not true sleeves, but formed by the fulness of the garment, which is practically nothing more than a square or oblong piece of linen taken from the loom, sometimes fastened by strings just below the breast, and sometimes girdled at the waist. They wore sandals, some with pointed turned-up toes like our skates, and some with points so long that they were turned back to the instep. Elaborately-plaited wigs, divided into three parts and bound by a fillet of linen, were worn by both sexes, the hair not being allowed to grow except in mourning. The ordinary Egyptian gentleman wore the loin-cloth, and a long, full, transparent chiton like his lady; but he also had a chiton with very short sleeves, and the loin-cloths were of various qualities and dimensions. The very close-fitting, non-transparent garment we see on many statues and statuettes is not, however, to be taken as illustrative of the fashions of the *living;* and in looking at all these records we must be very careful not to be misled by the artist's conventionalities, or his powerlessness to sculpture in the round the exquisite lightness and transparency of the drapery which floated round the limbs of Egyptian beauties a thousand years before Pheidias showed men the way to fashion in marble these flowing textiles. Besides the square or oblong loin-cloth (with its strings placed on one edge at a little distance from the ends), the skirt, or petticoat, and the chiton, with or without sleeves, we find also a transparent mantle or shawl or himation (as the Greeks called it), which was wrapped round the right side from arm-pit to ankle, and thrown over the left shoulder. Then there were varieties of

girdles, ties and sashes, the ends of some spreading out in a fan-like form, that may easily be mistaken for a part of the robe itself. The broad necklace like a collar or gorget, head-dresses, rings for the fingers and ears, bracelets and armlets were to be found in the full dress and adornments of the upper ten.

Among royal and priestly personages the apparel was much the same as that generally used by the upper classes. The distinctive features of the king's attire consisted of the apron and the crown, or head-dress.* The most distinctive sacerdotal garment was the leopard skin, worn over one shoulder and passing under the other. It was a part of the costume of the high priests in certain important functions, and was put on by the king when he officiated. The high priest—who ranked as king—wore the girdle of royalty, and a head-dress of peculiar form. The priests are found attired in very different ways, according to the functions they are engaged in ; sometimes they have very little on, and sometimes they are clothed very like the laymen of the upper class. Between the priest's sister and the queen there is often no difference to be seen, except that the latter has perhaps a longer girdle, and wears a head-dress with the asp (the special sign of royalty). The sacred scribes were distinguished by a fillet and one or two feathers on the head, but even these gentlemen had their undress, and did not always fare forth filleted and feathered. Some of the royal scribes wore a short-skirted and short-sleeved tunic, girded at the waist. The sacred emblem bearers generally wore a long full loin cloth, or a skirt, reaching to the ankles, tied in front with long broad ties, and supported by a strap of linen over the shoulder. The special mark of the princes was a badge at the side of the head descending to the shoulder, frequently finished with a gold fringe. But whatever men or women wore, from the king and the high priest to the lowest labourer, the linen or woollen loin-cloth, in some

The falling end of the sash or girdle became a permanent ornament.

shape, was common to all, and appears to have been worn partly doubled. Some of the dresses of the more important personages have narrow fringes; some show embroidered or woven pattern, and many exhibit the transparent material as either pleated or gauffered, although some of the lines on the dresses may possibly only mean the natural folds. The linen used was of many degrees of quality; from the coarse sail-cloth to that fine manufacture which won for itself the name of "woven air." That used in the burial of the dead (mummy cloth) is the only ancient Egyptian linen we know, and even this shows many qualities, some of it being very elastic, close, and firm, in one specimen the warp showing ninety threads in the inch, in another, one hundred and fifty-two; the woof of the first having forty-four threads, that of the second, seventy-one.

The fringes occasionally worn by the Egyptians were of delicate proportions, and consisted simply of the ends of the threads of the woof. In some examples where the fringes are long, the threads are twisted together and knotted just like those on the Eastern silk shawls now imported. But a fringe to a dress was a decoration by no means usual, if we are to judge from the monuments.

To sum up, the chief articles of ancient Egyptian dress were the loin-cloth arranged in various ways, the girdle of different degrees of richness and fulness, the long chiton with or without shoulder sleeves, and the himation. The material of which these were usually made was linen (*byssus*) of different qualities, and mostly white; there was nothing tight about the body except the girdle; there were no heels to the sandals, the soles of which were cut to the shape of the foot; and the upper garments, although of such light fabrics, were as a rule suspended from the shoulders. For two thousand years or more the nation saw no room for improvement, for the costume on the figures in the tombs of Memphis differs but slightly from that of the time of Rameses II., so far as the general public fashions are concerned. Such differences as may be

traced will, I think, be found chiefly, if not entirely, among the royalties and high official classes, after the crowns of Upper and Lower Egypt had been united in one remarkable head gear, and the girdle had been developed into the very important, elaborate, and ornamental accessory seen in the sculptures and paintings of the 19th dynasty.

For a hot climate, where the sense of decency did not include the entire concealment of the legs and arms, the Egyptian dress was fairly well adapted both on the score of health and in the cause of beauty; for however much we may stare at the strange pictures of Beni-Hassan, wondering wherein the beauty we speak of consists, I may venture to say that any one who will take the trouble to put the work into good drawing, to emancipate the old figures and free them of their rigid conventionalities, will assuredly discover that the costumes of the Nile Valley, when Joseph held office in the court of Phra,* were as beautiful as they were healthy. If there existed a defect, it was perhaps in the too general use of linen; but then they used it rightly, not covering it up with close-fitting over-garments, as we do, for had they thus prevented the free circulation of air, had they thus interfered with the warming and ventilating, I venture to think that the people would have been decimated by cold and consumption. It is time, however, that we passed on to consider the dress of other nations, for the space at my disposal will not allow me to go more into detail, or to speak of the many ornamental accessories, and of the survival of savage decorations such as rings pierced through the flesh of nose and ear. For all this I refer my reader to the great work of Lepsius, and to the splendid collections of Egyptian monuments at Boulak, and in the British Museum and the Louvre.

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Of Asiatic monarchies, the one which probably had the greatest influence in the history of costume was that of ASSYRIA. This kingdom, which did not really exist

* Corrupted into Pharaoh the word Phre, pronounced phra, means the sun.

until after 1800 B.C., is said to have been founded by Assur, 1900–1800 B.C., who had migrated from Babylon. But of its dress we know only what the monuments tell us, and those illustrative of costume do not carry us further back than the second Assyrian Empire under Assur-nasir-pal, B.C. 880, though the Chaldæan Merodach of the 12th century B.C. indicates the descent. It is therefore chiefly to the slabs and monuments from Nimroud and Kouyunjik (now in the British Museum), and of Khorsabad (now in the Louvre), that we must look for guidance. In B.C. 672 Assyria invaded Egypt, in B.C. 667 Assur-bani-pal * ascended the throne, and in 625 B.C., one year after his death, Nineveh was destroyed. The sculptured slabs show us the dress of the Assyrians from about 880 B.C. to about 650 B.C., during which time there was no change of any great importance. As in Egypt so in Assyria, the earliest monuments exhibit a high degree of civilization. On the banks of the Nile we found a hot climate, a people wearing but few garments, and those mostly of light transparent textures, made of unmixed flaxen linen, which, as the special textile of the country, was manufactured largely, not merely for home consumption but for exportation. On the banks of the Tigris we find great variation of temperature; a people clad, as a rule, with as few garments as in Egypt, but non-transparent, and a material which the heavy fringes alone sufficiently declare to be of woollen manufacture.†

On one of the Egyptian Theban monuments (see Wilkinson, "Ancient Egyptians," woodcut No. 457) is a figure of a man of rank whose dress consists of first a loin-cloth; over this a long, slightly transparent tunic reaching to the ankle, and having short shoulder sleeves; and over that a very thin shawl which enwraps the whole of the right side, and is thrown over the left shoulder (see fig. 1). Make

* The Greeks called him Sardanapalus, and in his time Assyria reached its utmost height of glory.

† Herodotus says the tunic was of linen; but we must remember he is speaking of the degenerate Babylonians in the 5th century B.C.

these transparent linen vestments of wool, ravel out deep borders of fringes, embroider a band, or apply a ribbon to prevent any further unravelling, and you have the ordinary Assyrian civil costume of men and women. The varieties obtained are due chiefly to the dimensions and management of this shawl or himation, and the nature of the waist-belt or girdle. Between King Assur-nasir-pal and his chief subjects there is little difference, except in the trimmings and his head-gear, and the only difference between the king and his god is in the head-gear and the length of the tunic, for the god, like the priest, wears a short tunic, the fringe of which just reaches the knee (see fig. 4). The god's head-dress is a round cap with horns; the priest's, a fillet or coronal; and the king's, a cone (probably of felt), capable of receiving various shapes, by turning up the lining at the base, and depressing the cone towards the point (see fig. 5). In looking at the pictured slabs from Nimroud, Khorsabad, and Kouyunjik, we have to make allowances for the Assyrian artist's conventional treatment, just as we had to do in looking at the paintings and sculptures of Egypt. The Assyrian, like the Egyptian, was still anxious to show us both ends of the cask at once; but artistic sensibility can be seen, even in 880 B.C., opposing this inordinate desire for information, and in little more than 200 years the artist's victory was assured in the wounded lioness of the sculptor of Kouyunjik.

The particular feature of Assyrian costume, which rarely or never escaped from conventional fetters, was its fringe trimming. In some cases it is shown standing out rigidly horizontal; in many we must take it that there are two patterns of fringe on the same hem, or we shall be driven to the conclusion that two fringes, one behind the other, must have been used; and in certain examples, it is hard to explain the sculptor's representation, except on the theory that certain long fringes were made, not as borders or trimmings, but to be used alone as scarves. This theory has its danger, for once accepted, we are apt to apply it whenever we meet with a fringe difficulty. Of this,

however, I am confident, that a large shawl about twelve feet by six feet fringed on its four sides, is capable of being arranged under proper management, so as to produce the form of the Assyrian shawl or mantle in its usual aspect, allowing that is for the sculptor's conventional treatment. Hunters, servants, and the mass of the male population, wore the short tunic with shoulder-sleeves and broad waist-belt. In the time of Assur-bani-pal (or Sardanapalus), many of the soldiers and hunters (see fig. 6) wore a sort of net to protect their legs, and a boot or gaiter curiously like the cothurnus of the Greek and Roman, laced in front over what looks like an incipient greave. The Assyrian sandal, as worn by the king's grooms, has a piece protecting the heel, and is tied across the instep with double thongs; as worn by the king himself, the heel piece is extended till it meets the sole near the toes. The design or construction is practically the same for king and servant, for both have rings upon the big toe, to which, I take it, the diagonal thong of the sandal was attached. The waist-belt is a part of the Assyrian dress of considerable importance. Its chief characteristic is its great width. A belt of the width shown on many Assyrian figures, if fashioned of leather or thin metal, would be a very material protection to the vital parts of a man's body. It is to be observed, that this belt as it increases in width is itself belted by what looks like an independent metal girdle, but which in some cases may be the narrow thong, or end of the broad belt doubled round. On the figures of important personages, and on men in the royal household, these belts are elaborately carved in imitation of embroidered, stamped or *appliquéd* pattern. I am inclined to the opinion, that they were sometimes made of stiffened linen, and even very thin metal,* although leather was probably the usual stuff employed. Whatever may have been the material, it may be remarked that this stay-belt does not show any signs of tight laces, or vertical ribs of iron or bone, but

* Narrow belts of bronze we know were used.

from its almost universal use we may not unreasonably conclude that this broad belt was found to be quite sufficient support to the body. Not only the belt, but the tunics and mantles of important personages, and even their horse-cloths, were often covered with figures of circles, thickly powdered over the field,* or diapers of hexagons and squares, but, whatever the shape, the pattern appears to have been always small and geometrical, both in its forms and arrangement. Another kind of decoration was effected by using fringes, not merely as border trimmings, but applied on the surface of the garment like flounces. The figures cut on the ivory panel from the South-West Palace at Nimroud show fringe used in this way, and as independent scarves. That some of these fringes were made of long fleece and of fur is possible, and, indeed, I cannot well see how we can explain some of the slabs, except on the supposition that the whole shawl or mantle was made of camel's-hair, skins of long-haired sheep or goats, or fur.

As in Egypt, distinguished people wore armlets, bracelets, earrings, collars of gold, and necklaces ; of these the cases in museums tell us but little, and in the sculptures they are treated as a rule with conventional uniformity. Like the Egyptians, too, the Assyrians were commonly bareheaded, wearing, however, their own hair in long elaborate wigs and beards. We see besides the crowns and helmets, fillets more or less ornamented, and a sort of round skull cap. A soft pointed cap with the point hanging down, is also to be found. It is the prototype of the cap of liberty, and is usually associated on the slabs with low boots, having turned-up toes. This, however, is not to be taken as an Assyrian cap, but as belonging to certain foreigners, who wear the long fringed chiton and himation, have long hair and beards, and whose country supplied monkeys or apes of a large growth ; thus indicating on the one hand Arabia, or on the other hand, a land south of the Himalaya. It is time that we turned to some of these foreigners, and enquired what they did in the matter of dress during the

* Like Japanese brocades of the present day.

long period of Egyptian and Assyrian civilization. Before doing this, I may point out that the military costume of Egypt and Assyria involved tunics of various lengths, covered with rows of large metal scales, helmets of various shapes, and in Assyria, chain armour, at least to the extent of a curtain to the helmet, like that which in the Middle Ages was known as a camail. The Assyrian soldier had also a jacket of plaited or twisted cords. The shields were of various shapes and sizes, some like bucklers, and others covering a man from chin to ground. The swords were broad, short and straight, the hilts and scabbards of those belonging to the king and his staff richly ornamented. The spear, the javelin, the bow and arrow, and the club or mace were also among their weapons.

Whilst the two high civilizations we have glanced at were in progress, what was the condition of the countries round about them, and in other parts of the globe? The historical period in China begins with the Hia dynasty, founded by Yu "the Great," about 2200 B.C., whilst the union of the states, in other words the Empire, dates only from 247 B.C. The first reliable date in the history of India takes us no further back than 300 B.C., although the West was directly acquainted with Hindustan during the reign of Darius, king of Persia, 521–485 B.C. Of the early civilization of these great countries, covering so many degrees of latitude, containing every natural product a nation could require, we know little; of their dress at that remote time (2000–1000 B.C.) we know nothing. Even of Persian costume, before 559 B.C., when Cyrus founded the Great Persian Empire, there is scarcely anything to say, although Persian history begins, according to the *Shah Nameh*, of Firdusi, in 1000 B.C. But westward of Assyria are countries where the people dressed in fashions of which we can glean knowledge as early at least as the reign of the Assyrian Shalmaneser II. (859 B.C). If, as some say with Herodotus, Homer wrote about 850 B.C., we shall gather from him something of the costumes of Greeks and Western Asiatics before the Greek colonization of Asia

Minor. Of the country lying westward of the Jordan and the Dead Sea, the land that flowed with milk and honey, we have in the Bible much and curious information as to the costume of its inhabitants. That there was a high civilization round the tortuous shores of the Mediterranean before Moses wrote or Homer sang has been clearly established. The ruins and the discoveries at Mycenæ and Hissarlik, the appearance of some of the "foreigners," who are pictured in Egyptian and Assyrian monuments as bringing tribute into powerful Thebes or mighty Nineveh, are quite enough to show that the arts of peace were in a more or less flourishing condition. Then, again, the dyes of Tyre, and the embroideries of Sidonian women, were famous before Shalmaneser invaded Phœnicia. But in all these countries, west of Assyria, so far as I have been able to trace it, the dress was in all essentials the same as that of Egypt and Assyria, viz. a loin-cloth, a tunic, and a shawl. These two last-named articles of apparel may be translated, coat and cloak, frock and mantle, chiton and himation; the quality of the material, the dimensions of the cotton, linen, or woollen stuffs used, and the nature of the trimmings, constitute the main points of difference. There are, however, two additions which we meet early in our path after leaving Assyria, the sleeve proper, and the trouser. I am inclined to think that we owe both to China. Be this as it may, the Persian sculptures at Persepolis show loose bag-shaped sleeves like those on Japanese tunics. You may remember that when we found the Assyrian tunic cut short to the knees, a network looking like coarse elastic hose was seen on the legs, and boots took the place of sandals. Now the Medes, and certain of the Western Asiatics (in Lydia and Phrygia) were still more careful of their legs when they wore short chitons, for they used trousers loose or tight, and often protected their arms by sleeves to match. This wrapping of each limb in a distinct bag may be a very early invention of the Chinese, as an additional protection against the severity of the winters in their northern latitudes. But the

appearance of these loose sack-like appendages could not have been other than offensive in the eyes of a people like the inhabitants of Western Asia, who followed after the beautiful, and certainly achieved the decorative at a very early period. We consequently find that in their hands the coverings for the arms and legs were after a time made so as to fit the limbs, like the buttoned sleeves and long hose of the 14th century A.D.

It is unnecessary to attempt a description of the dress of the Israelites or Arabians, the Hindoos or the Aryan swarms that had settled in Western and Northern Europe. The influence of these peoples on the development of costume was so slight, that it is hardly measurable by the side of the joint powers of Egypt and Assyria. But among the many tribes and kingdoms with whom these powers were more or less in conflict, one or two are remarkable for certain contributions. Thus, the Rutennu, or East Syrians, wore gloves or gauntlets reaching nearly to the shoulder, and are the first to appear in what may be described as long frock coats or ulsters, reaching to the middle of the leg, tolerably tight in the sleeve, and tied high in the neck: the Hittites invented the mural crown, wore low boots with turned-up toes, following in their fashions first those of Babylonia combined with touches from Egypt, and, after the wars of the Assyrians, becoming strongly influenced by the dress of the invaders.

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While these Asiatic civilizations were battling with one another, the Aryan swarms that had settled on the peninsulas of Europe were finding paths of their own in the great march of progress; and the first of these European peoples were the GREEKS. What they clothed themselves with, and how they looked in those early days when the Dorians were quiet in the north, and the Achaians were tilling the Peloponnesus, when the Ionians were busy on the land where Athens stands, and the old gods and heroes were but men keen of wit and strong in the arm, it is quite as impossible to say as to trace the costume of Egypt

before painting, or sculpture, or speech reveals it. The Mykenæ find of Dr. Schliemann shows the rosette and guilloche ornaments of the Nimroud find (880 B.C.), but in a degenerated fashion. There is, however, an ornament based on the equilateral triangle, familiar to the student of Chinese and Keltic work, but which I have failed to find on any monuments from the Nile or Tigris. That the sculptures from Assyria picture the dresses Homer describes more nearly than the earliest marbles or vases of the Greeks yet known there can be little doubt. Hera's girdle arrayed with a hundred tassels, Aphrodite's girdle broidered with figures, and Helen's great purple web whereon she worked battles between Trojans and Achaians, probably in bands that took the place of the Assyrian flounces of fringe, are a few among many instances of Assyrian colouring.

The early Greek dress, so far as we can know it from the Archaic monuments, is, again, like the Assyrian and Egyptian, a very simple contrivance; and the figure of the Egyptian man of rank in Thebes (fig. I.) is the type of Greek and Etruskan costume as it is of Assyrian. The fringes which the Assyrians added, the Greeks removed, putting embroidered applied or woven borders in their place. The materials employed were chiefly woollen goods of home manufacture. We find also linen of hemp and flax from different places, leather, and later on silk from China, by way of Persia and Phœnicia to the Island of Cos. Making due allowance for the conventional treatment of the early Greek artists, we gather that the wool fabrics were of various textures, but not generally transparent; that the girdles were neither broad and folded like those of the Egyptians, nor broad and stiff like those of the Assyrians, but either like tape, or narrow and round in section as if made of cord; that until the time of the first Persian war (490 B.C.) the Ionians—following the Assyrians—wore short shoulder-sleeves to their chitons, a fashion that remained for centuries with the lower classes; for although it involved a little more shaping, it took considerably less material than the chiton, which was

doubled round the body and fastened by clasps above the shoulders. The length and breadth of a chiton appear to have been very variable; but most of those commonly depicted on the vases (see figs. 7, 8, and 9), and in the sculpture of 500–400 B.C., seem to have been made out of one piece of stuff, measuring about ten feet by five; in other words, the height was about equal to the distance from the nose to the ground, and the breadth double the distance between wrist and wrist when the arms are extended laterally. There is no shaping, or "making," in a dressmaker's sense, the whole art is in putting it on, in the method of clasping it, in the girdling and the delicate touches which lift the rippling folds here and there, so as to make them fall a little over the girdle. You can be *shown how* to do this, but no *words* I have control of can describe it in such a sure way that it would be impossible for any one to go wrong. And here, as we are threatened with much classic revival, I would take the opportunity of saying, that there are in these days, and in North-Western Europe, few figures, especially among the middle and upper classes, than can for a moment compare with those of the countries and times we have been rapidly glancing at; and the reason of this will be apparent as we go further in our survey. A really well-grown, healthily-developed figure can undoubtedly be clothed to look like a statue by Pheidias, but not certainly by any forced contrivance or machinery of pins and stitches, strings, and tapes. It is necessary to observe that a Greek lady wore under her chiton nothing, or next to nothing. In early times, possibly, nothing. As time rolled on we find a broad band or belt worn next the skin to support the breasts, and over that a thin vest, while sometimes we see a loin-cloth or short drawers, like those worn by an acrobat. Then came the chiton with its girdle, and the in-door costume was complete. The chief out-door garment was the shawl or himation, in size and shape, possibly in texture, very like the Rampore Chuddah shawls of the present day. At the four corners were small weights, to assist the wearer in throwing it, for

to put on or throw the himation was a part of the education of every Hellenic girl. To put on the himation, the long end was first thrown over the left shoulder, the other end might hang to the knees or even to the ground; the himation was then unwrapped and brought round the right side under the arm, the lower edge reaching to between the knee and the foot; it was then gathered across the body in groups of folds, tightened across the right side by a dexterous pull, and by a still more dexterous movement, the long end was finally thrown over the left fore arm or shoulder. This was the usual fashion; but it was worn also as a veil, or as a wrap encircling the body and both arms. The Tanagra terra-cottas in the British Museum exhibit a great variety of ways of wearing the himation, and the many different arrangements we see on vases may be traced either to the particular throw, the quality of the material, or the dimensions of the shawl. The usual size appears to have been, as already stated, about ten feet by five feet, and not much more than twelve feet by six feet for exceptionally large ones. In the Panathenaic frieze the peplos (which is only another name for a large-sized himation), is shown folded up in squares of about two feet, according to scale; and judging from this, and as far as I can from the edges, I should say a shawl of twelve feet by six feet might have served as a model to the sculptor. The girdle is another article of the Greek female apparel, which was arranged in various fashions. At first it appears in Greece and Etruria as a plain and rather broad band (600–500 B.C.), but this Assyrian reminiscence does not last long, and gives way, about 500, to a narrow girdle of cord, a quarter of an inch in diameter, or of a ribbon-like belt from one to two inches broad. Some girdles were made of thin bands of metal, and some of a string of beads or pearls; but those of the best period (470–420) were simple cords of hemp or wool, with perhaps a gold thread from Persia intertwined. For the feet the sandal, shoe, and hunting boot were used, and although no stockings are shown, that I am aware of, on Greek vase

or statue, one cannot deny the existence of socks as early as 500 B.C., in Etruria, after an examination of the lady's legs on the sarcophagus found at Cære. Of the round hats made of soft and stiff material, of the head-dresses and caps, and of the modes of wearing the hair adopted by the Hellenic ladies, there are many varieties, but at the best period of Greek art the simplest fashions prevailed; for although the shape of their clothes varied but little for one thousand years, the ornaments, details, and material changed considerably. There was, however, one important addition made to the female costume at an early date, which endured so long, that it is found in its simple form on the monuments of Theodosius II. (A.D. 408–450). This addition was dictated by the laws of hygiene, and consisted in *doubling* the thickness of the material over the vital parts of the body, either by making the chiton long enough to double over to the extent of thirty or thirty-six inches, or by employing a separate piece of stuff and wearing it over the body of the chiton like a loose jacket. In cold weather, or mountainous regions, two *διπλοΐδιον*, as these jackets were called, were sometimes worn, and even instances occur of two chitons, the upper one being rather shorter and narrower, showing fewer folds than the under one, which was made full, so that if the open side were sewn up it would still allow the free action of the limbs. Other slight changes may be traced to the differences in climate, and to the fashions of the people in chronological, geographical, or in commercial contact with the Hellenes.

One great and early distinction is in the length of the chiton. The Ionians wore it long enough to reach the feet, following the early Assyrian and older Asiatic fashion. If ungirdled, such a chiton might trail on the ground, and the large himation could be arranged to trail, whenever its wearer desired. The hardier Dorians wore the chiton short, never reaching below the knees; but after the Persian war, the Dorian women used the long Ionian chiton, only the girls retaining the shorter skirt. Then, a few years later, or about the time of Pericles, the Athenian

men forsook their long chitons and adopted the Dorian. Henceforth the great European distinction between male and female dress was to consist in the length of the skirt; old men, priests, and officials being allowed the privilege of wearing long, or women's skirts, and young girls being permitted to wear the short, or man's skirt. Of the embroidered, woven, and applied decoration; of the coloured glass ornaments and thin metal plates that were sewn on the early dresses; of the rich figure bands with chariots, horses, and men that striped the whole himation; and of the charming powderings and diapers, I have no space to write. It would be here, however, that we should find how Greek costume had its styles or periods, and how these were chiefly due to the measure and kind of decoration employed. In personal ornaments and jewellery the Greeks followed after the Assyrians and Egyptians. They wore ear-rings, finger-rings, necklaces, bracelets, armlets, and brooches; but in the best period the light delicate handling of the workman, not the weight of the gold, was the criterion of value. It is hardly necessary to add that among the working classes the chiton was made sometimes of coarse homespun and sometimes of leather, while fishermen and certain slaves wore the rough hide. The linen chitons of the ordinary citizen rarely reached as far as the knee, and the himation was worn by the men as well as by the women; but warriors wore a smaller kind, shorter and narrower, more like a scarf, which was called chlamys (χλαμύς), and was worn sometimes loose and sometimes fastened on the right shoulder by a brooch. Men's hats or caps were used as a rule only by youths, mechanics, and slaves; *as a rule*, for Hermes is sometimes represented as an old man wearing not the usual round hat (πέτασος) of the shepherd and hunter, but a conical cap, probably of felt, with a brim peaked in front and turned up at the back, exactly like the *bycocket* used in Mediæval Europe during the 14th and 15th centuries, and which, in a slightly modified form, survives in heraldry as the cap of maintenance.

* * * * *

Passing westward to ETRURIA, we find the dress singularly like the Greek, the chief points of difference consisting in the absence of the diploidion. The chiton appears at first as if it possessed short shoulder sleeves, only they are slit up on the outer side, and joined together again by loops and buttons, which shows that the dress is like the simpler form of the Greek chiton, an oblong piece of stuff doubled round the body. The himation and chlamys instead of being cut square seem to have been smaller and rounded, the Etruskan himation, or *tebenna*, as they called it, reaching only its utmost size and complete development in the Roman *toga rotunda.*

* * * * *

In fashion and material the ROMAN dress was in direct descent from the Etruskan; but already we may perceive the thin end of the wedge, which eventually destroyed all the simplicity, and beauty, and hygienic quality of the Greek costume. In the history of Roman attire, we find the influence of a colder climate than that of Athens; the ladies were not content with the Greek vest as an under-garment, but turned it into a close-fitting chiton, or tunic reaching to below the knee, over this came the broad breast belt, or *mammillare*, and over that a second tunic, which they termed *stola*, and which was in fact the Roman equivalent to the 19th-century robe or gown. The stola was made in the same manner as the Greek chiton, and girdled like it. On going out, they threw on the *palla*, which was the same as the Greek himation, but probably larger. In addition to this, a veil for the head, made of a detached piece of stuff, was sometimes worn by rich people. Like the Greek ladies, the Roman beauties devoted much time, patience, and invention, to the arrangement of their hair, using dyes and false hair, especially during the time of the early Emperors. With the decline of the Hellenes rose the use of cosmetics, and in the extensive use of paint for the face the Romans certainly surpassed the Greeks. Shoes were beginning to be more used; but socks, although well-known before 500 B.C., were for a long time considered

a superfluity. Jewellery was worn to an enormous extent; and in this as well as their gold ornaments, it was the value of the material, not the quality of the work which was the chief consideration. The fabrics of their dress were confined to wool and linen up to the end of the Republic; later on silk was imported from Cos, but of a texture which is perhaps best described by the word gauze, and this commanded such a very high price that it was scarcely seen outside the Imperial circle.

The Roman male costume, although consisting of only two garments, a short-skirted tunic and a toga, was yet much more extravagant than a Greek's dress, owing to the quantity of stuff absorbed by his toga. The Greek himation measured 4 yards by 2 at the outside, but the toga measured no less than 15 feet by 10, if Weiss's dimensions (Costümkunde), the result of many experiments, may be accepted. From my own experiments, I should say that the size of the toga varied; that in its earliest days, when worn without any other garment, it was not much more than 12 feet by 8, while in later times it reached an amplitude even greater than that represented by the figures quoted from Weiss. The shape of it is now generally supposed to have been oblong, with the angles rounded off so as to make the ends nearly, if not quite semicircular. Before putting it on, one of the long sides was folded down so as to make the length equal to twice the breadth, and this fold was kept uppermost, that it might be within easy reach to lift over the head as a hood. The general arrangement on the body proceeded on the same plan as that of the himation, and the art consisted in the management of the folds, to assist in which small weights were used, but neither pin nor clasp. It must be remembered, however, that the toga was almost a semi-official costume, for free citizens only was it permitted: the distinction between male and female dress, generally, being quite as marked in Rome as in Athens after 480 B.C. To the year 390 B.C., when the Cisalpine Gauls defeated the Romans, we may attribute the introduction of the *pænula*, a kind of cloak not unlike the

poncho, reaching to the knee, and made of thick warm material. The mantles called *trabea* and *sagum* were borrowed from the Greek chlamys, and, like that, were used by the military; although a larger kind of trabea, called *paludamentum*, was reserved for the general-in-chief. The earlier Roman tunic was so like the Dorian chiton that we may pass it without further comment.

The common colour of the higher class Roman dress was at first white, indeed a toga could not by law be of any other colour, but the natural undyed colours of the wool, of the white and black sheep (which would be yellowish brown, and dark grey) were those of the dresses worn by poor people, slaves or freedmen. The white toga and tunic of the leading magistrate and many other officials (under the Republic) were decorated with a purple or blood-red hem or border, and the commander-in-chief's paludamentum, or mantle, was altogether red. Remembering that in the streets of Rome the background of these few simple colours was mainly terra-cotta, we can with little effort picture to ourselves, at least the colour effect of both costume and scenery. Under the Empire certain changes early appeared in the dress of the wealthier classes and the military. The toga reached its fullest amplitude when the *sinus*, formed by a voluminous fold, appeared in it, crossing the chest from right to left, and so large that it served the purpose of a tolerably capacious pocket. The *toga picta*, and the *tunica palmata*, the festal offering to the Jupiter of the Capitol, had been worn by the chief of the army in the triumphal processions under the Commonwealth. After 27 B.C. these were permitted to the consuls, prætors and tribunes on special days. Gradually, as the toga became an old-fashioned thing, and gave place to garments of less unwieldy dimensions and easier put on, it was looked on with that peculiar veneration with which some of us in this day regard our great-grandfather's wardrobe, the wig, coat, breeches, silk stockings, and three-cornered hat of a century ago, and thus we find that, like these, it was reserved for special functions or state occasions, for old fashions in

dress seem to have always found a refuge in the ceremonials of the Law and the Court, and within the walls of the theatre and the circus.

Thus, the first important change under the Empire was the general substitution of the mantle or cloak for the toga. As the toga is to the Greek himation, so the cloak, which the Romans termed *pallium*, and the Gauls *sagum*, is to the Greek chlamys; both of these later draperies being rounded and enlarged editions of their Greek prototypes. But this mantle in a curtailed form was worn as a military garment in the days of the Republic, it having no doubt been found necessary by the Roman, as by the Greek, to protect the metal plates of his cuirass from the burning rays of the sun. The shape of it was an oblong with one straight side, and the other corners rounded off, so that when laid flat it approached the form of a semicircle. The central part of the straight side was arranged round the neck and usually fastened by a brooch (*fibula*) on the right shoulder, so that the right arm could be entirely free. The two corners of the larger kind hung front and back to within a few inches of the ground, when the arms of the wearer were kept straight down. When, however, it was desired to free the left hand, the mantle was raised on the left side until it cleared the wrist and fell in a group of folds from the arm: the points or corners of the mantle would thus be elevated to halfway up the leg or higher, according to the position of the arm. The common funeral cloak of modern times is the outcome of the Roman pallium.

The tunic, as already pointed out, was at first a replica of the Greek chiton, but about 190 B.C. sleeves were added to the tunics of both sexes. These sleeves were of various lengths, from that which reached nearly to the elbow to that which touched the wrist. Under the Empire the sleeve most commonly met with is one that reaches about halfway down the upper arm. And here we have to note the influence of silk as a material for dress, and of the luxury and extravagance which came in its train. Just before the Empire was established, the ladies of Rome

were beginning to wear dresses of silk, as well as of golden tissue, imported at a very great cost: it was not long before the men followed their example; a law was enacted to stop men from using such costly stuff, but, like all sumptuary laws, it only tended to increase the extravagance it aimed to correct. Certain of the Emperors themselves were, however, tempted to clothe themselves in silk, and hence, instead of using, as of old, one tunic of thick closely woven wool for winter, we find two, three, and even four tunics worn one over the other. A purple hem was no longer sufficient distinction, for the tunic now bore vertical stripes. One broad purple (blood-red) stripe down the centre, called *clavus latus*, distinguished the members of the upper house or senators; two narrow purple stripes (*clavus angustus*) marked the order of knights. Another change of importance to be noted is the introduction of breeches (*braccæ*); not trousers or bags like the Gauls, rather loose and reaching to the ankle, where they are occasionally fastened like the neck of a bag or sack, and which the Roman soldier sometimes wore; nor tights, like the Amazons of Lydia, and the Persians pictured at Pompeii; but close-fitting veritable breeches, reaching a few inches below the knee. Colour under the Emperors invaded the simplicity of the old Roman costume. At least thirteen shades of the dye obtained from the murex, which passed under the general term of purple—shades of blood-red, violet, the favourite amethyst, and dark sea-blue, the last named being the most highly prized—could be seen in tunic and mantle of both sexes; there were also to be found scarlet, light blue, yellow. Indeed, the white toga became unfashionable as early as the time of Caius Julius Cæsar, who was the first to clothe himself in the toga of the imperial purple (blood-colour) called *blatta*. Hats or caps were even at this period by no means commonly used except by the poor, or travellers; for the Romans, like the Greeks, preferred to avoid the encumbrance of any special headgear, using a fold of the toga or mantle when necessary.

The limits of this little handbook will not permit me to

FIG. 1. FIG. 2. FIG. 3.

show how varied were the personal ornaments and decorative accessories of this period. I can but enumerate a few, such as the strings of pearls used in the hair, the pearl or jewel-enriched ribbons, the golden wreaths, the elaborately-carved hair-pins, the richly-adorned boots, both high and low; shoes and sandals, with their straps winding round the leg, and not to be confounded with the crossed hairy thongs of Goths or Franks; necklaces, chains, rings, brooches, mirrors of metal, bracelets, charms and charm cases (*bulla*). Of the cosmetics or the different pomatums, pastes, powders, and scents; of the rice and bean-flour mask to remove wrinkles, or the potency of ass's milk, and of the artificial teeth or the false hair, I must not write. The antique world was already a thing of the past: the old order with its refinement, and beauty and simplicity, when the cunning of the embroiderer was of more value than tons of gold tissues, was giving place—indeed, had given place—to the new order, with its piles of costly, but worthless properties; a new order of things, where

FIG. 4. FIG. 5. FIG. 6.

quantity of hard-to-get stuff was more prized than the harder-to-get thought that could fashion the stuff into joy-giving things of beauty.

The costume of the Romans under the Empire, which we have just peeped at in a very cursory manner, had an influence so widespread, that no other national influence of the antique world could in this respect possibly compete with it. This influence, however, was of two kinds; westward, extending from Britain to Africa, it worked powerfully, and the Roman habits and customs entirely overwhelmed the conquered nations and became rooted in the lands. But eastward, the old Greek civilization was far too beautiful to be wiped out by any mere military power; and the civilizations still further east and south, were too old and too steady to be seriously imperilled.

During the time of Augustus Cæsar an event occurred at a crowded inn in a small town of Judæa which was destined to influence, not merely a tribe or an empire, but both hemispheres, for no one can study the history of dress

FIG. 7. FIG. 8. FIG. 9.

without perceiving that the wild extravagancies and the effeminate luxuriousness of it, which grew to such height in the palace of a Cæsar, and which all through the Middle Ages continually recurred, were only successfully turned, kept under, or combated by the teaching of the Christian Church. In its infancy and early days of persecution, we find this Church condemning, with no uncertain sound, the fashions of the time, the costly array, the excessive attention paid to hairdressing, and the over-adornment with gold and pearls. With the decline of the Empire these vulgar, because immodest, displays of finery increased; the mantle was no longer a simple drapery, depending for its beauty on its more or less accidental folds and their natural lights and shades, but was stiffened by two large squares, embroidered and often covered with pearls and precious stones, applied on the straight side of the mantle, so that when the garment was on, one square hung across the chest, and the other across the back. The borders of the tunic were loaded with jewels and plates of

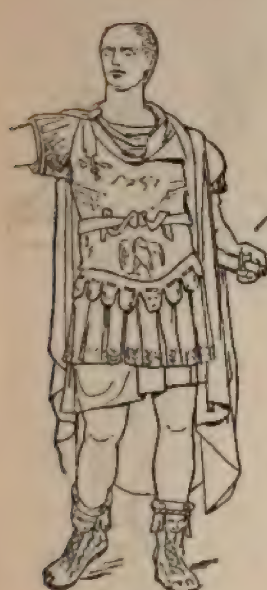

FIG. 10.

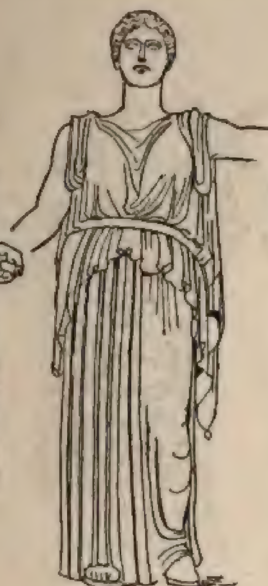

FIG. 11.

FIG. 12.

gold ; the stuffs themselves were made heavy and stiff with woven patterns of gold, further weighted with pearls and stones ; until through all this rank overgrowth it was hard to believe that the costume was in direct descent from the most beautiful the world has ever seen. The custom of the Romans to "decorate" the breasts of their victorious soldiers by covering them with what they called *phaleræ*—circular metal medallions often in high relief,—no doubt contributed to make heavy medallion patterns fashionable, for military dress and civil costume are constantly found reflecting one another. So that by the time we reach the death of Theodosius the Great, when the Roman Empire was dismembered (A.D. 395), we have before us a style of dress which can neither be called European nor Asiatic, and which for convenience we call BYZANTINE (see figs. 13, 14, 15) :—a style which seems to have flourished only in the important towns of the Mediterranean, for the country folk both sides of the Bosphorus still continued to wear the chiton-diploidion and the himation, and to

FIG. 13.

FIG. 14.

FIG. 15.

look much the same as their ancestors did eight centuries before. Though the old Byzantine dress lingered on for some hundreds of years, though we see it in the mosaics at Ravenna, in Venice and Sicily, in Asia and Africa, though it went through a history of its own, associated with the Greek branch of the Christian Church until it lost itself in utter barbarism, it had no special effect worth recording on European civilized dress except through the textiles of Sicily, whence its influence as regards pattern and ornament was of long duration.

Meanwhile the example of Rome to her northern or Trans-alpine provinces in the matter of dress, was as marked as her influence on its architecture. Before 60 B.C. the greater part of Gaul had not come under the yoke of Rome, and was inhabited by various tribes of the Aryan family, the oldest of them being the Kelts, who had been pushed westward by successive waves, and still in our day surviving in the Welsh, Irish and Bretons. The first to thus push them was the Aryan swarm, known as the

FIG. 16. FIG. 17. FIG. 18.

Teutons, under which name may be included the Germans, Danes, Swedes, Norwegians and English, all of whom were first settled in what is now known as Germany. Another wave of Aryan migration is known by the word Slavonic, and yet another by the term Lithuanian. It is impossible to review the early dress of these peoples, for our knowlege of their civilization is too limited to speak of it with any certainty. Whatever their dress might have been, it is tolerably clear that it was wholly unable to survive the power of Rome; of their military equipment we know something; their circular shields, their bronze, leaf-shaped spear-heads and swords, and even their mode of fighting, remind us of the early Greeks more than of any other people. With something like certainty we can picture the Kelt and the Gaul of a later period, as Julius Cæsar saw them; and the sculptures on the columns of Trajan, Antonine and Theodosius (A.D. 100–400), show that their style, already assimilated to that of Rome, had changed but little in four centuries—trousers, a short tunic


FIG. 19.


FIG. 20.

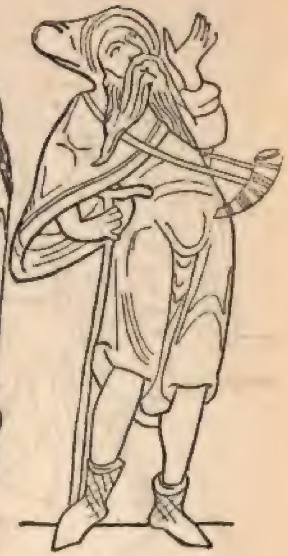
FIG. 21.

(dyed of different colours), a capacious mantle and a loose cap, constitutes the costume of the elders or chiefs. The material of their dress was wool of different qualities, woven in stripes or squares of dyed yarn, although the under classes were for the most part clad in skins, chiefly of the ox, the bear and the sheep—not after the manner of savages, but because they were both economical and warm. The personal ornaments of the upper classes consisted of torques, rings, diadems, bracelets, necklaces, armlets, belts, and brooches: some of gold, some of bronze, some of bone and ivory, and some of a material known as Kimmeridge coal.

* * * * *

In A.D. 469 the Roman influence had done its work. At this time the kingdom of the FRANKS had been founded by Pharamund about fifty years; sixty had passed since Rome had been captured by the Goths under Alaric, and forty since Roman and Christian Britain had invited the co-operation of Teutonic and heathen tribes (afterwards

FIG. 22.

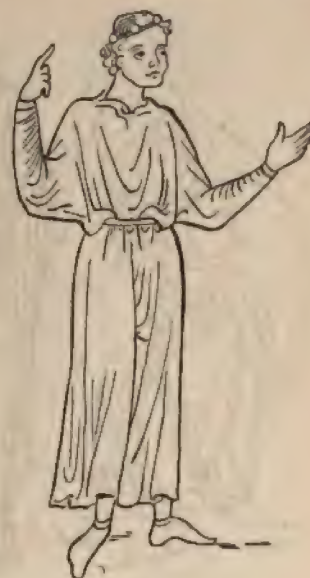

FIG. 23.

called English or Saxons), who eventually pressed the Britons into the corners of the Northern and Western promontories, and made the country their own. Hitherto the flow of fashion had been chiefly from the East and the South. We have to note the two opposing Teutonic waves, which now met it from the North and North-East. The withdrawal of the Roman troops, about A.D. 410, was the signal for the descent on Britain of those hardy, fierce, brave heathen tribes, who were to make this country their battle-ground for the next six hundred years. Very different from the Gauls and Romans were these men from beyond the Rhine. We find with them, in 469, neither loose trousers nor tight breeches, their legs were bare, except for certain hairy thongs they wound about the feet and ankles to protect and strengthen them in walking or running; their woollen tunics were short, with short shoulder sleeves like the Assyrians of the time of Assur-bani-pal; they bound round their tunics skins of beasts studded with metal. Men of rank wore, in addition, a short cloak or

FIG. 24. FIG. 25. FIG. 26.

mantle, sometimes fringed, and among their weapons we find barbed iron spears or javelins of a peculiar form, axes, long knives, bossed circular shields, and swords hung from the shoulder by tightly-fitting belts. The Romanised Christian ladies of Gaul and Britain wove for themselves woollen dresses, fashioned after the double tunic or chiton-diploidion, in separate pieces, and the palla or the mantle of the Romans; the heathen ladies of Germany seemed to have been clothed with even greater regard to the coldness of the climate and the honour due to them—if, that is, we may be permitted to argue by analogy backwards. From A.D. 469 some considerable time passes before we meet with any authentic representations of these peoples, whether Franks or Angles. Tombs have here and there been opened that speak of the golden splendour of the fabrics of the 5th and 6th centuries, and the weaving and the embroidery of the English women in the 7th century were famous even on the Continent. The almost naked arms and legs of the bare-headed Franks of 469 were gradually

FIG. 27.

FIG. 28.

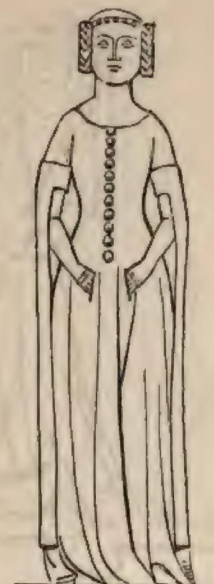

FIG. 29.

covered up, and the costume of the Christian-Frank, and Englishman, after A.D. 600, loses its roughness, and with this a great part of its picturesqueness. The full or complete dress may be described as consisting of a shirt (*roc*), a tunic reaching to the knees and commonly cut longer in the sleeve than the arm itself, so that, when in place, the lower arm was surrounded by numerous little folds; a short mantle (*mentil*), which was so far like the Gaulish sagum that it was worn in the same way, and usually fastened by a fibula or brooch over the shoulder; a waist-belt or girdle, breeches (*brech*) reaching halfway down the thigh, *hose*, shoes (*scoh*) or boots, leg bands crossed or plain, and a cap of Phrygian shape, but stiffish in make and not loose like the British cap. Distinctions of rank were marked not by any change in the make, but in the quality of the material and the enrichment of the tunic and mantle by means of borders, bands, and circles often of real metal. The ladies' dress consisted of a long tunic, with sleeves exactly like those

FIG. 30.

FIG. 31.

of the men's tunic; the kirtle, which I take to be another name for a shortened tunic when worn under a long gown; a super-tunic or gown, also worn short or long, in opposition to the tunic's length, with sleeves gradually widening and a little longer than the upper arm; a capacious mantle; a veil or, rather, head-cloth (head-rail), and gloves. Here, also, distinction was achieved by using costly material and rich borders, which were often of gold tissue. In the make of a man's tunic, especially in the later examples, one notices that the body is more or less tightly-fitting like a jersey; that the skirt hangs in folds, and is sometimes open at the sides and rucked up round the waist, concealing the belt; that it was put on over the head, being open a little way down the front so as to admit the head, and that the neck was cut high and fastened with strings.* In the illustrations of legs there are many varieties shown of protecting them. Some have the leg-guard, garter, band, or thong bound round continuously,

* There was another kind of tunic (not common), shorter in the skirt and with short full sleeves.

FIG. 33. FIG. 32. FIG. 34.

like a coil, from heel to knee; others show it crossed like an open plait. Either way shoes are worn; closely fitting the foot, open on the upper side, and laced from instep to toes. There are figures where the lower part of the leg shows a sort of stocking rucked up into narrow folds like the tunic sleeve, and with these also we find shoes worn—this, however, may be only the hose slipped down; and there is yet another kind where the leg guard takes the form of legging or gaiters, tightly fitting, except at the top, where they open out and are decorated with a deep border, but this last is extremely rare. The hair is worn long and wavy; the beards, pointed or bifurcated, and the moustachios long and drooping. The ladies wore their hair long and flowing, and had a goodly supply of bands for it. Golden armlets, bracelets, necklaces of coloured beads, were common; and some had gold coins as pendants between the beads.

To the civil costume warriors sometimes added a coat or tunic covered with rings of metal, but with short open sleeves;

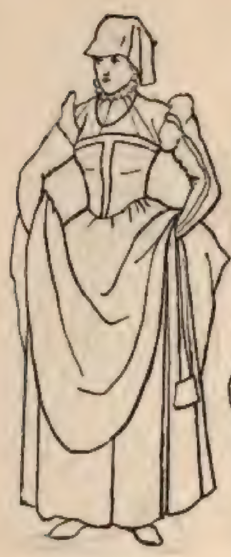
FIG. 35.

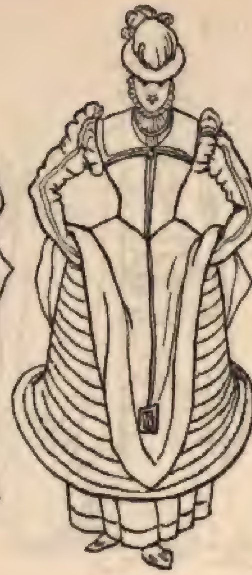
FIG. 36.


FIG. 37.

and others, particularly young military men, wore over the ordinary civil tunic a short-sleeved jacket with scalloped edges, which appears to have been made of skin or leather. The helmet was not common; and where it is shown of a conical form it may be taken as felt, strengthened and protected by metal bands. The circular bossy shields, the broad, long, straight swords, and the barbed javelins and spears of the 5th century were their chief weapons. The axe of the old Frank was changed into a bill, a *twy-bill* or double axe was added to their armoury, and the knife assumed the dignity of the dagger.

Among the old Frankish and English materials for dress we find a lady's gown or jacket of otter skin, various kinds of woollen cloth, plain and striped muslin of different qualities, linen coarse and fine, a twilled material like serge, ribbed braid of twisted threads, and many patterns of gold braid of different widths, varying from one-fourth to three-fourths of an inch in width. Silk and cloth of gold would be found in the royal and chief ecclesiastical ward-

FIG. 38. FIG. 39. FIG. 40.

robes. The clerical costume was in no way different from the lay except in the functions of the Church, and then there is little difference between it and the ladies' dress in general appearance; the tunic of white linen (*alb*) reaches the feet; the super-tunic, gown, or *dalmatic*, reaches to little below the knee. Then came some changes clearly Roman in their origin. The clavus angustus appears on the super-tunic, the two narrow stripes woven in or sewn on; over the tunic we see it again in the form of a *stole*, the mantle is circular, like the Roman pænula, and bears the broad stripe or latus clavus, and hence the *chasuble*, the arch-bishop wearing a *pallium* instead; which, being gradually reduced to its neck piece and its latus clavus, was then called a *pall*, and worn over the chasuble. Last of all was the large mantle, capa or *cope*, which was of the same semi-circular shape it has retained ever since. The cope and the dalmatic were also royal vestments, and splendid 11th-century examples are still preserved, and are admirably

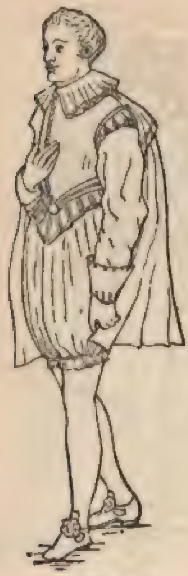

FIG. 41.

FIG. 42.

FIG. 43.

illustrated in Dr. Bock's work on the 'Coronation Robes of Germany.'

* * * * *

The English and the Franks seem to have been fond of bright heraldic colours, red, blue, green and a rich violet purple relieved by white and gold. Over this there soon passed a melancholy wave from the shores of Denmark, for the national colour of the DANES was black, and their standard was the Raven. The heathen Northmen or Danes began their ravages on the Christian English at the close of the 8th century, just as the heathen Teutons had descended on Christian Britain in the 5th century. To the Vikings England unquestionably owed an improvement in her military equipment. They appear to have had helmets with nose-pieces, coats of chain-mail and of ring-mail sewn on leather, spiral armlets a foot long, bows and arrows, besides the old Frankish armoury of spear, axe, sword, dagger and shield. When they had found a firm footing in England, the brilliancy of the English costume and the

FIG. 44.

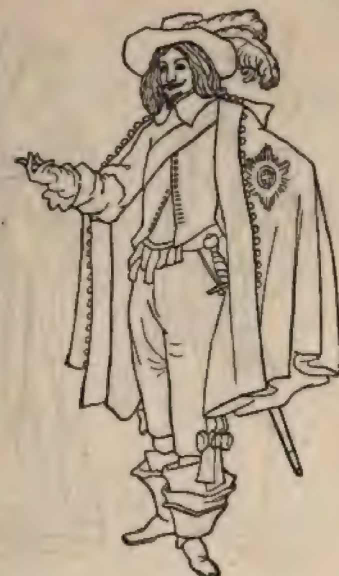

FIG. 45.

beauty of the English women began to influence the Danish dress. Certainly by the end of the 10th century it is evident that the distinctions between the Danes and the English, whatever they might at first have been, have for the most part disappeared. Silk at this time began to take a more prominent place in Northern costume; coronation and ecclesiastical vestments were made of it, and its whole surface was richly embroidered in gold and pearls, with fruit and flowers, and birds. It may be remarked here that one of the very highest enjoyments for the ladies was to paint with the needle either on silk or linen, the picture of their husbands' great deeds, for needlework, like the Bayeux tapestry, was by no means an invention of William the Conqueror's kith or kin.

While the English were fighting the Britons on the one side, and combating the Danes on the other, the Franks had established a kingdom for themselves in Gaul, to be united to Germany under the Frankish king, Charles the Great, who was crowned at Rome Emperor of the West in

FIG. 46. FIG. 47. FIG. 48.

A.D. 800. At this time North-Western Europe might be said to be broadly divided into two styles of dress, the old Teutonic dress beyond the Rhine, which had never been under the direct influence of Rome, and the Frankish costume in Gaul, which rapidly assimilated the Gallo-Roman style. From the split up of the Frankish Empire during the 9th and 10th centuries, many of the national costumes of Western Europe date their departure either from the Roman or Germanic mode, and the history of the Mediæval dress cannot be fully understood until we have read it, so to speak, in every language.

* * * * *

As far as one can see, the dress of the MIDDLE AGES started fairly enough; and in the costume of A.D. 1000 there is little to complain of on the score either of beauty or health. It is true that some men tattooed their skin contrary to law, and, in spite of the Church, wore long hair; but I am not prepared to say that these practices are worthy of condemnation, if they be carried out with due

FIG. 49. FIG. 50.

attention to design and cleanliness. The most objectionable article of English dress from the hygienic point of view would have been the leg-bandage, or cross-gartering, for any tightened straps carried over the surface of the body or limbs of a man must be injurious. It need not, however, be supposed that these bands were worn all day long, and every day. I take it they were really leg-guards, equivalent to the high boot and gaiter of our own time, and only adopted in certain out-door occupations, as of the fight or the chase. The hose, in little folds round the leg, outlived the band as a general leg-gear for the higher class, but even these had their garters knotted and tasselled below the knee. The hose with feet, or as the Norman called them the *chaussés*, were probably used towards the close of the 10th century, in combination with short drawers; but the leg bandage appears as late as 1066, and in a somewhat modified form still later, surviving to this day in the pattern of the Highland sock.

We observe that in the first half of the 11th century

FIG. 51.

FIG. 52.

the quilted or ring-covered tunic, though used in 966 by particular and distinguished warriors, had proved so serviceable, that it had become the general costume of the cavalry and the spearmen. But we also find that in 1066, if not earlier, it had received the very important addition of a cowl or capuchon, and to this military tunic the Normans gave the name *hauberk*. The kite-shaped shield was borrowed from the Sicilians, in the beginning of the century, and, like its original, often bore, in the manner of the old Greeks, the figure of some animal, such as the lion or griffin. To the close of the century throughout Western Europe little change took place, for the armour in the grand Spanish MS. of the Apocalypse, executed in 1109, and now in the British Museum, is precisely similar to that shown in the Bayeux tapestry.

The ladies' dress was much the same as in the days of Alfred or Cnut. The body of the robe or gown, like that of the 10th-century tunic, worn by the men, was tight-fitting, and the skirt hung from a waistband in many small folds.

FIG. 53.

FIG. 54.

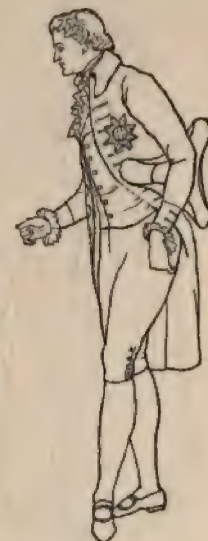

FIG. 55.

You will remember that the ladies' 10th-century gown or super-tunic had short full sleeves, under which were seen the tight narrow folds of the tunic sleeves. This short sleeve the Norman ladies exaggerated, at first by simply enlarging and lengthening it, and finally by suddenly dropping it at the wrist, so that it resembled a long loop. This utterly useless and ugly *maunch* is the first of many stupid fashions Europe has endured for the last 800 years, and took its rise, like most stupid fashions, in the vulgar love of exaggeration.

Ecclesiastical dress during the 11th century shows two changes; the dalmatic is open at the sides, and the mitre is foreshadowed in a flat cap of some soft material, which, stiffened by a band round the head, is depressed in the crown, and has the two pendant bands, *infulæ*, or *vittæ*, with fringed ends reaching to the shoulder.

The 12th century witnessed many changes in costume throughout Europe. Among the people we find distinct improvements, and greater consideration in providing

FIG. 56. FIG. 57. FIG. 58.

against inclement weather. Thus, short boots, and a cape (*capa*) reaching to the waist, and fitted with a cowl, are added to the sleeved tunic, shirt, drawers, and hose of the people's wardrobe. All these, with the exception of the boots, were usually made of wool, home-spun, or frieze. The upper class in North-Western Europe began to be affected by Eastern luxury, brought prominently to their notice through the First Crusade of 1094. Thus the tunic was lengthened, and increased in width, both in body and sleeve. The full dress of the men trailed on the ground; the sleeves were about ten inches longer than the arm, gloves were constantly worn, and costly fur was used as linings for the fine woollen cloths of the winter mantles. We find fillets instead of hats or caps, boots and shoes lengthened considerably at the toes,—a fashion set by the Count of Anjou, about 1090,—and much time wasted in devising peaks, tails, twists, and curls, for these long excrescences. Such a dress, combined with long, artificially-curled hair, reaching below the shoulders, might well be

FIG. 60.

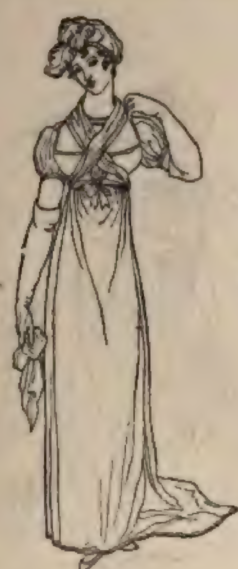

FIG. 59.

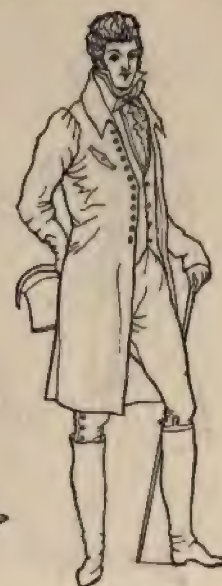

FIG. 61.

deemed effeminate, but whether it was enough to justify the decidedly strong language indulged in by the Bishop of Sèez, on Easter Day, 1105, as reported by Ordericus Vitalis (Book XI. ch. xi.), is questionable; although, judging from the monk's chronicle, it is not improbable that the dress was associated with a mode of life neither sweet nor reasonable.

The military were also subject to the Eastern fashion of increased length of skirt, their tunics reaching halfway down the leg, and their cowled hauberks nearly as far. A new arrangement of rings on the hauberk—setting them edgeways—belongs to the beginning of the century, and the cowl was so cut as to cover the chin.

* * * * *

The ladies' dress during the first half of the 12TH CENTURY closely resembled that of their grandmothers and great-grandmothers. The sleeve went on increasing in length, until it had to be tied up, to prevent the wearers tripping over it. The skirts of the robe assume a train-like

FIG. 62. FIG. 63. FIG. 64.

length ; the body is still fitted tightly and laced sometimes up the back ; the arms and neck of the tunic, or under-garment, are often gauffered and pleated ; the mantle is cut in a widened semicircle and fastened with cords in front ; and the gown is decorated (1) by a long rich girdle sometimes doubled round the body, knotted and hanging in two ends nearly to the feet, and (2) by rich borders on the hems, and at the neck.

There is little or no alteration in ecclesiastical vestments, but the monk appears sometimes in a curious kind of large pænula with a cowl, and with the sides cut up to allow freedom for the arms, the slits thus formed being joined together again by three or four loops. (See fig. 19.)

The second half of the 12th century was a period of transition and development in all the arts. From the Romanesque, or round-arch style, was now slowly developed a new school of architecture, known in our time by the terms *Pointed*, or *Gothic*. With this movement all other arts,

FIG. 65.

FIG. 66.

including that of dress, had their share. The king and his nobles appeared in long tunic with tight sleeves; super-tunic nearly as long, with loose but not long sleeves; a waist-belt, with long pendant end; a mantle, usually long but occasionally short; gloves, hose, and short boots. The war harness of a knight was, in 1150, a coat of mail over a long tunic, and very like what I have already described; but towards the end of the century the under-tunic disappeared; a surcoat, generally of silk, was worn over the mail hauberk; the conical helmet gave place in England to a flat one, with a visor (*aventaille*) opening like a door; the *gambeson* and *haqueton*,—quilted tunics of leather,—were worn with and without the hauberk; the long kite-shaped shield was shortened, its semicircular top cut straight, or nearly so, and on its face heraldic bearings appeared. The ordinary civil dress was limited to a shirt, a long tunic girded rather low, a mantle, hose, drawers, and shoes or boots. Caps or hats were not common, except in inclement weather. The ordinary lady's dress, as visible in contemporary illustrations, consisted of a tunic; a super-tunic not only without sleeves (*bliaut*), but

FIG. 67. FIG. 68.

open at the sides, and fastened at the hips; a wimple or kerchief, a low broad-brimmed hat, gloves, and short boots or shoes. The tunic or robe loses the tight elastic look about the body, and assumes the looser character of the later Roman tunic, seen on ivories, of the middle of the 5th century; it is tightly girdled, and from the belt hangs the *aulmoniere* or bag. A medium thin silk (*ceudal*) was used for the garments themselves, and for lining cloth or woollen dresses; fur was also used in the same way. *Samite*, a thick silk of six "threads," was to be found in the wardrobes of the nobility, and the armoires of the large churches; other silks of different qualities, some of light texture, with gold in the woof (*ciclatoun* or *cyclas*), and some with woven patterns in one colour (*diaper*), were among the materials used in castle and cloister.

* * * * *

The 13TH CENTURY is the classic period of Mediæval art. We cannot go far in the study of its monuments—the buildings, miniatures, paintings on tile or plaster, sculptures,

and the few articles of furniture, dress, textiles and embroideries, without our becoming convinced that the old Frankish influence had by that time spent itself, and that the first revival or Renascence of that Greek beauty which cannot die or be wholly forgotten dates from the general adoption of the looser and longer tunic. Dress now began to be somewhat distinctive apart from its decoration, and we are thus enabled to separate the different classes. Even in the rough reed-pen drawings of the time we see that in the inspection of a building in progress, the king alone wears gauntlet gloves; that his architect wears a mantle and a long tunic; while his chief workmen wear only short tunics, hose, shoes, and sometimes hoods. The lawyers and the students or graduates of the universities, the members of the different religious orders, and the merchants, exhibit characteristic costumes, alike free from extravagance in design and material. Even kings, judging from their effigies, weie robed in garments of classic simplicity as to cut or shape, but, reasonably enough, made of materials of highest value, such as *Baldakin* or *Baudekin*, a fabric of silk and gold manufactured at Baldak, now Bagdad (of old, Babylon). This stuff was in appearance like cloth of gold, shot with various colours; but it must have been much softer and more flexible than what we now know as cloth of gold, or it would never have hung in graceful folds.

Samite, embroidered and fringed with gold, was also to be found in the royal wardrobe, together with furs for lining purposes, those of the ermine, marten and squirrel having been, in the 13th century, added to those of the sable and others that are found in older inventories. An ordinary gentleman of the middle of the 13th century wore in summer a linen shirt with sleeves, and reaching halfway down the thigh, drawers fastened either just below or just above the knee, hose, shoes, and a long full tunic with tight sleeves to the lower arm, but cut very full under the shoulder; although it should be remembered that at the beginning of the century the tunic did not possess the fulness and that classic character it attained toward 1250.

His hair, worn flowing, was bound by a fillet, and his tunic was girdled at the waist by a narrow belt, the skirt being open in front, sometimes as far as the waist. In cold weather, if walking, he wore a super-tunic; if riding, a cloak or mantle, the fastening brought over the shoulder, leaving the right arm free; a hood, a conical hat with the brim turned up, and gauntlet gloves. (See fig. 22.) When the summer tunic was made of the thin glossy silk called *ciclatoun*, or *cyclas*, it was known by the name of the textile employed. Among the poorer class we find that the shoulder-cape, with attached cowl or hood, was a common out-door garment; that the tunic was short, scarcely reaching the knees; and that low-crowned, broad-brimmed hats, much like some of our modern felt hats, were used, when the weather was fine and the protecting cape could be left off. The coif or white skull-cap, tied under the chin, occurs constantly. In military circles the coats of mail were not always used, but knights adopted instead of it, tunics and leggings (*chaussés*) of cloth, or leather, or silk, quilted and padded. The ring mail had been wholly abandoned, and the new chain mail, brought from Asia, was *de rigueur*. Helmets were increased in size, until they rested on the shoulders; small *plates* of metal appeared on the mail in the middle of the century, the foreshadowing of a complete revolution in the knight's equipment throughout Western Europe, of another Renascence, heralded by the revival of the almost-forgotten armourer's art.

The ladies of 1250 wore in the house the tunic and the sleeveless super-tunic; the mantle, veil, and frequently the wimple and hat being added for out-door and state costume. The super-tunic, like the tunic, was put on over the head; it was open in front from the waist downwards, open at the neck a little way, and there fastened when on by a lace. Shoes and gloves were common, and stockings of cloth were occasionally worn.

The materials included, besides woollen fabrics, thin gold tissues, many kinds of silk, fine and coarse linen, muslin—a fine cotton, so called from being made at Mosul

in Asia, and various kinds of fur. The favourite colour was green, but red, white, blue, purple and gold, though not so common, are yet repeatedly seen. A round conical cap, with a little button on the top or apex, appeared early in the century, and many of the artists of the time have indicated the button conventionally by drawing the dome of the cap in one line of an ogee form. This was the outcome of a loose soft cap of conical shape, which, being pressed down an inch or two of the point stuffed with wool or tow, stood erect, as in the Assyrian crown. Another invention of the century, which I mentioned just now, was the great-coat, or super-tunic (*supertotus*) with long cape and hood attached. It reached to within a few inches of the ankles, and in rough weather must have been a very serviceable garment; lined with fur, the hood drawn over the head, long warm gauntlets on the hands, a man might have been tolerably comfortable going from London to Durham, even though his coach or wagon travelled at mere walking pace.

Towards the end of the century the tunic begins to lose its classic character, and again to be shaped more or less to the body. In the 12th century, as we have seen, the body of a lady's tunic was close-fitting, and the skirt pleated into a waist-band placed low down. In the latter half of the 12th century the waist-band was abolished, and after the looser tunic had reigned for a time, the *gore*, which had in a certain rough way been employed in the skirt of the men's tunic during the 11th and 12th centuries, was more fully recognised and developed. This was the prelude to tight-lacing. The waist-belt, no longer a constructive part of the dress, became an ornamental accessory and was occasionally omitted altogether. These changes, however, were not universally adopted all at once, for the looser tunic had its adherents side by side with the followers of the new fashion during a considerable period. Indeed, it may be said that it has never since been wholly abandoned, for the French blouse and the English smock-frock are little else than 13th-century tunics in a degraded form. The ladies'

dress of the age we are now glancing at was both simple and elegant; first the tunic, or gown, high in the neck and tight in the lower sleeve, with a few buttons towards the wrist, and over this either the sleeveless bliaut or super-tunic (surcote or cyclas), with full but shorter sleeves. If the tunic had a train, then the over-garment was shorter; but if the gown only reached the ground, then the length and train were given to the upper garment; although in some examples both tunic and super-tunic appear to be equally long. Above these in cold weather or on state occasions a mantle was worn with long cord fastenings. Although many ladies wore their hair loose and flowing, without ornament of any kind, except perchance a fillet or garland, yet we cannot but see that invention began to be busy with the head-gear. The caul or net, which was revived not long since, became general; we also find the gorget-wimple, very like that still worn by nuns, the banded headdress, which gives somewhat the appearance of the head having been strapped up by a surgeon, the *couvrechef* or kerchief, arranged in more than one way—very prettily worn in Italy—and the plait, beginning at the temples and sometimes encircling the head like a wreath.

The moderation, the modesty, the repose, the grace, in two words the beautiful reasonableness of costume in England and Italy during the last quarter of the 13th and the first years of the 14th century cannot escape the student's notice and admiration. In France and Germany a certain amount of eccentricity appeared, and it is to these nations chiefly that we owe the outrageous inventions that began to show themselves in the 14th century, increasing in quaintness during the 15th century, until in many cases they became positively uncouth, in spite of the scorn of the satirists, or the thunders of the Church. That the personal character and influence of the highest personages had much to do with the local tone of European fashion there can be no doubt. Our own king Edward I. (1272–1307) dressed on ordinary occasions like one of the people, in woollen cloth, and his queen was the *beau idéal* of graceful simplicity.

So, too, in the great commonwealths of Italy, men and women alike were noticeable for the low esteem in which they held extravagance, finery, and anything approaching mere personal display. The chief alterations in the gentleman's attire consisted in the greater use of buttons, and in the adoption of a shorter tunic, more like that of the 11th and 12th centuries. It was cut high in the neck and buttoned down the chest, the sleeves of the lower arm were fastened at the wrist with four or five buttons, and the waist sometimes girdled. Over this was worn occasionally a short cloak with hood, but more frequently a rather loose, long surcoat or super-tunic, with or without a hood attached, having short, full sleeves, open in front. The two noteworthy head-coverings of this time were the *bycocket*, which we have already seen worn by Hermes on a Greek vase, and a newly shaped hood (*chaperon*), worn not like a hood or cowl, but twisted up into the form of a flat cap with a pendant end. Shoes and low boots were worn fitted to the natural shape of the foot, and mostly buttoned. Here and there we meet with charming little varieties in both male and female dress, as in the cut of the super-tunic sleeve, the shape of the cuff and the neck, which, as the century advances, attracted more and more the decorator's attention.

* * * * *

In Italy the tunic or super-tunic of the gentleman of the 14TH CENTURY has almost invariably a high stiff collar with three or four small buttons under the chin; both garments are open in front and fastened with buttons and buttonholes, thickly set as a rule, although instances occur of double buttons and loops. The white skull-cap or coif which we always see on Dante and the Doge of Venice was almost invariably worn by persons of rank, or by men holding any official position. The super-totus of the last century, with its cape and hood, underwent a slight modification in the 14th century, the cape part, front and back, being omitted, and the sides of it which fell over the arms being incorporated into the body of the garment, giving in certain

views the appearance of full hanging sleeves, not unlike the modern Inverness cape. The earliest illustration of this I know, occurs in an English manuscript of the 13th century now in the British Museum; but it does not appear to have come into anything like general use till about 1310, from which time we find it a favourite; and surviving nearly to the end of the century. And wisely so, for even in its modern and degraded shape, there is no garment in a man's wardrobe which is so near the beautiful and the healthy. In its original form it fell in graceful folds, and combined warmth with ventilation; the skirt was open in front, and there was an opening at the neck, where also we see the germ of the modern coat lapels. Another overcoat of this time had very long hanging sleeves, with openings high up under the shoulders, so that the arms could be free without the necessity of putting on the outer sleeves. As the century advanced into its second half, the short tunic or undercoat (*cote-hardie* or *jupon*) was made shorter, and to fit the body (I am speaking only of the upper classes) as closely as possible, the whole front being open and thickly buttoned, the sleeves also thickly buttoned from the wrist as far as and sometimes beyond the elbow. The belt was passed through a loop or otherwise fastened at the back, and encircled the hips instead of the waist. Hoods, worn hood-ways, with small capes, were common, and the point of the hood was lengthened considerably, until it reached the dimensions of a long tail (*liripipe*), which could if necessary be wound round the neck or head. The mantle was worn by the most distinguished people, but instead of a single fibula on the right shoulder, a short row of from two to six buttons with loops, and sometimes two rows appeared. (See fig. 26.) There was yet another variety of sleeve fashionable about 1334, and which appears to have been worn by both sexes, and on both the under and over-coats or tunics. Its peculiarity consisted in a strip (*tippet*) of the stuff of the dress, of no fixed length, hanging from the elbow—a quite useless appendage. Another piece of inappropriate finery was the scalloped or leaf edge on

mantle and jupon, which "cut worke" was carried to so great an extreme during the 15th century. The tight lacing of the body of the ladies' gown led, as early as 1340, to a new cut of super-tunic, where the sides were not merely left open as in the bliaut, but sliced away so as to expose as much as possible the pinched-in waist—a quite newly-invented type of beauty, for which the narrow-bodied weasel served as a simile. In this century the apron (barme-cloth) made its first appearance, parti-coloured dresses and hose became common, and by the time the last quarter of the century had been reached the old beauty and simplicity were fast ebbing away. Before the year 1400 dawned, the fashion of dress had grown so generally foppish and extravagant, that cleric and lay, poor and rich, were alike infected. Velvet had come into use, and fur was lavishly employed; the "good Queen Anne" brought from Bohemia to England (1382) much unnecessary costliness in her train, heraldic bearings and mottoes were embroidered over the dresses, boots were laced high on the leg, and, worse than all, the tall hat of Burgundy, although then of soft material, was introduced into England by Henry of Lancaster.

The military equipment of the 14th century is chiefly noteworthy for the gradual change which the armourer's art brought about in the substitution of plate for chain mail, and for the withdrawal of the loose surcoat in favour of the jupon. I have not space to trace this change, nor to enter even on the much smaller development in ecclesiastical or official vestments, such as the growth of the mitre, and of crowns in general, monarchical or republican. We have passed the highest point of beauty and health that dress has ever attained, henceforth the story is in the main down hill. Up to within a few years of the period to which I have all too roughly conducted my reader, the human frame was recognised in its natural development, and as a rule clothed and cared for in a fairly reasonable and civilized manner. Any change of fashion had usually been dictated by considerations touching the comfort and protection of the body, and not by an irrational vanity, or

a stupid desire to appear like something different from the mould mankind is made in. The downward course dates from the day when the people—millers, reves, and such folk—thought it lady-like, pretty, genteel, to have a body small as any weasel. Up to then ladies had used from time to time, especially in the 12th century, a rational amount of tight lacing to their bodices, sufficient to make them close-fitting. Well-nurtured, well-bred, healthy women would of course look well in such a dress, for there would be in them no shapelessness or superabundance of flesh. As time rolled on, this tight-fitting bodice was associated with good birth, or fine breeding, and hence a small waist became at last a sign of gentility. If the women were coarsely bred, or had more or less tumbled to pieces, what matter? the body was elastic, the ribs were not nailed into their places, and a sufficient amount of steady pressure applied day after day would ensure them—naturally fine-shaped, finely-bred bodies? Certainly not; all it gave them was a mere veneer, a false gentility.

* * * * *

The 15TH CENTURY witnessed the introduction or development of many other evils besides that of excessive tight-lacing. The use of costly material impoverished many a house that could ill afford it, for we find, in 1404, men without rank or office wore cloth of gold, velvet, large and long hanging sleeves touching the ground, gowns trailing in the dirt, and winter dresses lined throughout with ermine. A little later the fashion of cutting or indenting the edges of the dress had become so general, that it was made a criminal offence in England for a tailor to make them; but where a people blindly give themselves to a fashion, laws are eluded and statutes are of no avail. We cannot deny that there was a certain amount of stateliness in the costume of the first quarter of the 15th century. The merchant in his jupon, with long-cuffed sleeves, his cassock-like coat all buttoned down before, his voluminous mantle and many buttoned hood, his handsome and serviceable waist-belt, his beaver hat of Flanders make, and his short-pointed

strap-fastened shoes, was as dignified as the makers of great commercial cities would need be. The comptroller of customs, or the clerk of works, in his loose pilch or overcoat with bag or *poke* sleeves, high collar, and chaperon, presented nothing frivolous, unhealthy, or extravagant, unless he chose to exaggerate the fulness of his sleeves, the height of his collar, and the length of his chaperon. The robes of judges, the furred gowns of both sexes called in French *pelisse*, and in English *pilch*, as indeed much of the dress of sober-minded people, might well pass both hygienic and æsthetic examination. It is in special features, and in the costume chiefly of the ladies and the young men about town, that we meet with fashions as unbecoming as they were unhealthy. Thus, among noble ladies, turbans and horned head-dresses developed later on into tall, heavy, heart-shaped, or conical structures, which produced startling effects; the sideless gown was reduced in its bodice to mere straps of fur; and the sleeves and train were of inordinate length. Young nobles, especially in France, again reverted to shoes with long-pointed toes, indented the borders of their garments deeply, girdled low, and generally affected floppy, limp attitudes. (See fig. 31.) Germany was perhaps more startling in her exaggerations than any other country; and before the middle of the century had arrived, was brimming over with eccentric fancies. That some of these eccentricities might have been overaccentuated by the painter is possible, for, in Italy, Michael Mattei shows us dresses bordering on the ridiculous, while Fra Angelico gives to fashions not very different, both grace and dignity. One of the earliest instances of the stiff roll pleating which is such a characteristic feature in the dress of the second half of the century, occurs before 1446, in a picture by this artist; but even Angelico could not make it look other than heavy, hard, and stiff.

Fashion now was not so universally followed by the nations of Western Europe as before, and indeed in one and the same country diverse habits existed at one and the same time. So much was this the case in Italy and Germany that

one might not unreasonably conclude that certain families retained special advisers, whose chief duty was to devise something, no matter how absurd, which would make their patrons look different from everybody else. Soon after the middle of the century, the skirt of the doublet or pourpoint in France was reduced in length to the smallest dimensions, and was forthwith copied throughout England, Belgium and Italy. The waist was tightened more and more, radiating pleats or folds were formed front and back, the sleeves made loose, and a cut or slash made in it, so as to pass the arm through at the elbow, or below the shoulder which was padded. This slash soon extended to the whole length of the sleeve, and then the opening thus made was fastened together at intervals by tapes or ribbons, or laces, called *points*. Under the doublet was worn a jacket, having a high stiff collar, and rather tight sleeves,* cut at the elbow, through which the loose white shirt sleeve protruded. Thus was started the fashion of puff and slash, which was carried to such extremes a century later. Instead of the doublet, very exalted persons wore a long gown reaching to the feet, but with the body and sleeves made in the same fashion; and slight heels began to show themselves.

The cut of the ladies' dresses in the latter part of the 15th century is remarkable for its diversity. No two dresses seem to have been exactly alike. The neck was cut in many ways, but the square cut was probably the latest to be invented, as it was the one destined to survive. Not only was there this restlessness, this feverish desire for change in the shape of the dresses, but it extended to the colour and the pattern. The latter began to grow in size, until in the following century it reached dimensions which were out of all proportion to the human body, and only suitable for the lofty hangings or curtains of palatial buildings; while the scale of colour, though not quite so extensive as that we now possess, for it was free from the

* Sometimes of different material and colour from the body, and surviving in the ostler waistcoat of our day.

horrors of aniline dyes, included besides the old colours many new varieties of greens, purples and reds, a tawny colour and an increased proportion of black. Towards the close of the century a costume entirely of dark grey, relieved sometimes by touches of gold or black, appears to have been worn by the *élite* of Spain—an early symptom of the grey and black melancholy, which, in spite of every effort made to oppose it in the 16th, 17th, and 18th centuries, has absorbed nearly all the old brightness and cheerfulness of male attire, west of the Adriatic.

It is quite impossible to follow here the many little changes of fashion, civil and military, at this period; but the later and more marked styles of civil dress were, strange to say, copied in metal, and armour is fluted, even slashed in imitation of the flutes, pleats, or folds and slashes of the cloth or velvet doublet. It is curious, however, to note that through all the changes, there is no real practical fashion, which by any stretch of the imagination could be termed classic. The Renascence was in full swing before the 15th century closed, the great painters of the Quatro-cento had already placed on their canvases Roman generals and Greek-like chitons; Mantegna, Botticelli, and their contemporaries, had evidently grown impatient with the inflexible material before them, and had accordingly invented for their models simple dresses free from the stiffening of pearls and embroidery, and in form founded on the old statues of Greece and Rome; but the public never really adopted this classical or Renascence dress of the painters. Pollaiuolô mixed the classic diploidion of the statue with the stiff brocade sleeves he saw in daily wear, but the people would not have even a compromise. Before the 15th century came to an end, many men wore a looser and longer kind of doublet or coat, open in front and turned back, giving the appearance of wide lapels; the high stiff collar was in most cases abandoned, and both the civil and military costume look as if made for a bigger, broader kind of men.

Our attention has been confined to Western Europe

partly because of the limited space at my disposal, and partly because in Eastern lands, fashions or styles in art were of particularily slow growth. The story of Indian dress might very well be the subject of a handbook by itself. No doubt the Aryans in the North were much the same as their neighbour Aryans, to begin with. What view the aboriginals of the South had on the subject of dress, history does not say. There are, however, some remarkable points of contact between India and Assyria on the one hand, and India and Egypt on the other, which the student of costume will not fail to note; as, for example, the fish-god and the man-lion, the transparent* dresses and the important part played by the girdle. Even at the present time it requires very little alteration to turn an ordinary Delhi native's dress into the full dress of the Ionian, for he throws the himation as of old, has merely put long close-fitting sleeves to the chiton, and added turban and trousers. Indeed loose trousers, or the divided skirt as it might be called, is the most constant sartorial mark of the Turanian races, and much of the peculiarity of Indian dress arises from the constant overlapping and mingling of the fashion of the two great branches (Aryan and Turanian) of the human family. In China and Japan are still preserved the heavy and light forms of Eastern costume in its pure Turanian descent, a costume wherein sleeve and trouser, and sash-like girdle play more important parts than in any other country, and the shawl, or himation, is, as a rule, unknown, except among the sacerdotal class. It would undoubtedly be curious and interesting to trace the costume of the far East, to endeavour to unroll its history, and explain the distinctions dictated by ordinary etiquette, state ceremonial or religious function; but except in its lovely textiles and their beautiful patterns, Asia has had practically no effect on the dress of the rest of the world.

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Returning to Europe, we find the 16TH CENTURY was

* The Indian sculptors exhibited the human form as if it were nude, and were scarcely able even to suggest the film-like drapery.

much less disturbed by the vagaries of fashion than the century immediately preceding it. At first there was no great perceptible change from the style which prevailed at the close of the 15th century. The stomacher, or shirt front, becomes a more marked feature, and the turn-over lapels of the overcoat are continued round the back, thus forming a broad-collar or capelet. But before 1518 ***trunk sleeves***, fastened with points to the body of the coat, and ***trunk-hose*** appeared, which laid the foundation of a very distinctive and long-lived style of male costume, for trunk-hose in one form or another did not go out of fashion in England till 1625, when fringed ***breeches*** took their place. Another important change occurred shortly before 1547, when the shirt-front or stomacher disappeared behind a new article of apparel named the *waistcoat*, which was provided with sleeves, and cut high in the neck. Puffs and slashes were extravagantly applied as early as in the first quarter of the century, especially in Germany and Switzerland. Coats, doublets, and waistcoats, were *garded*, or braided, and were sometimes covered with ornament, particularly embroideries of Venice gold, so thickly done that there was little of the ground colour to be seen. But the trimmings, the "fierce vanities" (as Shakspere calls them) of the dress of the first half of the 16th century, were so numerous, so costly, and so elaborate, that merely to catalogue them would fill many pages of print. London copied Paris with her accustomed exaggeration, and Paris, in her turn, outdid Italy and Spain. Before the middle of the century, we hear of knitted silk "stockyngs of hose,"* while the *ruff* began some considerable time before this, to bud in the shape of a ruffled edge to the shirt at neck and wrists. In this modest form it divided the honours for many years with the plain turn-down collar, and it was not till near the close of the century, that it blossomed into the stately and elaborate frills of Italy or the huge collars of England. As the century advanced, the short overcoat, with its broad, flat turned-down collar, gave place

* Knit silk and worsted stockings do not appear to have been *made in England* before 1560–1561.

to a short coat or cloak with piquant stand-up collar (see fig. 37); the waist of the doublet changed, and was made tighter and to slope downwards from the hips; the body of it was stuffed out with padding, to give it the outline we call pigeon-breasted, and which survives in the figure of Punch; the skirt of the doublet was reduced to a mere border, and the strap and tab gradually encroached on the slash and puff. Hats and caps were of various shapes, and the beef-eater and the "pork-pie" caps are but survivals of two forms.

The ladies' dress in the first half of the 16th century was, like the gentlemen's, in every way superior to the fashion which succeeded it. From the quantity and quality of the materials employed, the gowns and robes were no doubt extremely heavy when worn with sleeves and trains of such ample dimensions as those shown in some of Holbein's portraits. But it must be always borne in mind, that even royal ladies did not, as a rule, go about in such stately fashion; nor did kings, in spite of the teaching of the stage, always wear crowns and coronation vestments. In England, dress, during the first half of the reign of Henry VIII., was never awkward or outrageous, except when in certain extreme cases it was crowded with trimmings, and the soft flowing beauty of velvet or satin destroyed by following the old Byzantine error of overlaying it with stiff gold and jewels, a vulgarity of extravagance rarely or ever found in Italy. This stiffening process came at last to occupy the attention to the exclusion almost of everything else, so that about 1580, we find the entire dress (body and skirt) stretched over ribs and hoops, and the maiden Queen enveloping herself in that monstrosity, the farthingale (*fardingale* or *vardingall*), which had come from Spain, by way of France and the Low Countries, to England. In the last quarter of the century, Italy was the only nation in Western Europe that fully escaped the danger of making itself ridiculous in the eyes of posterity. If the student of costume turns to Venice (see figs. 39 and 40) he will find the peculiar characteristics of the dress

of the time, in their due place, and proportion, not forced to their utmost extremes as in England and France. We can hardly contemplate the *contemporary* portraits of Queen Elizabeth without experiencing a certain amount of sympathy for the poor body and the poor feet that had to endure, even for an hour, such a costume as that shown in Oliver's drawing or Zucchero's paintings of her. So different was it from the charming dress she had been used to wear as Princess, and even in the early days of her reign, that a lenient and hygienically-minded judge might look very charitably on the unevenness of temper, the cruelty, and even the dissimulation she displayed, and refer not a little of her shortcomings to physical derangement, caused by the weight she had to carry, and the whalebone-prison in which she was so often immured, In the 14th century women endured, or enjoyed, tight lacing in its simplest denomination as an exaggeration of the means of fastening the close-fitting gown. With the "revival of learning" women soon learnt how ignorant their ancestral relations of the 14th century had been in compressing the body out of its natural mould, without at the same time providing a new mould. Forthwith, with buckram at first, and then with whalebone and steel, the upper half of the hour-glass was fashioned, which yet, strange to say, survives in our enlightened age under the form of corsets. After the ruffled edge of the shirt had grown, and become detached as a ruff, a finer linen than that hitherto used in north-western Europe was manufactured. Cambric, so-called from being made at Cambray, and Lawn came into general use, and with them starch to stiffen and wires to support the fine fabric into fan-like or fin-like forms. About the same time, the point, or cut-work lace (*lacis*) of Flanders and Italy, left the retirement of the cloister for the world, and very high heels* became fashionable. The Italians *used* these things, the English *abused* them ; and if my fair reader wishes to see how to use lace and cambric, she should

* Derived from the patten, chopine, or clog, put on originally to protect the shoe in traversing muddy places.

turn to the Venice of Vecellio, not to the England of Elizabeth.

Before we pass on to the 17th century we will glance for a moment at the armoury of the latter years of the 16th. The first thing that strikes us is that defensive armour for all practical purposes was nearly played out; the breast-plate, the open helmet, or *morrion*, as the Spaniards called it, with here and there some *tassets* or thigh-pieces, were almost the only things used in war. For the tournament and ornamental processions complete suits were at hand; but the extensive use of powder and the variety of fire-arms had wellnigh put an end to the practical armourer's art, and left him a mere decorator. The introduction of the musket gave a new kind of picturesqueness to the military costume, in that it brought with it the *bandolier*—a broad belt worn over one shoulder, and having suspended from it a row of leathern cases containing the charges of powder; while the removal of the leg armour led to the general use of buff leather boots reaching to the knee. Now it was that the navy began to exhibit a distinct costume.

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The beginning of the 17TH CENTURY showed but few changes; but before the first quarter had expired we find that the tall or conical hat was generally preferred to the low flat cap; the ruff began (first in Spain) to give place to a broad plain collar (or *bands*) somewhat like the collars of certain dresses worn in 1550–1558. This was wired and stiffened with starch (coloured yellow in England), and occasionally edged with lace. The strap and the tab were generally accepted for the slash and puff, and the trunks or breeches beneath the straps were made very full and round with padding. Costly extravagance could not go much farther, for one ducal suit alone cost no less than £14,000. Jewels glistened over every part, and special importance was given to the hat-jewel, which had been worn in the last century, and which Benvenuto Cellini and other Italian artists had so exquisitely fashioned. Cloth

stockings were superseded by those knit of silk, worsted, and thread. In army-clothing there was at first little change; but Gustavus II. (Adolphus), King of Sweden, 1611–1632, was a military genius in whose eyes freedom of movement was the prime requirement in a soldier's dress; and though it took some time to break down old prejudices, supported as they were by powerful princes and potent ministers, his views, as we know, ultimately prevailed, except in the cavalry, where the light cuirass and helmet—the only metal defence he allowed—still linger as the sole survivors of the old war harness and its panoply of plate.* The ladies continued to be dressed much the same as they were in the last years of the preceding century, except that garded or braided gowns became more general, high heels were more generally used, the bodice, low cut in the neck, was tighter and more peaked than ever, and stays were worn as a separate article of apparel.

Soon after the second quarter of the 17th century a new costume arose, and we turn naturally to its great delineators, Velasquez and Vandyck, Rembrandt and Rubens. Stiff formality gave way to elegance, and heavy grandeur to a light yet sober looseness. The skirtless doublet was worn; but the modern frock coat is easily to be traced in the short-skirted coat of 1640, although it then possessed full sleeves tight at the wrists; the trunk-hose changed to moderately loose breeches (or rather short trousers) fringed at the knees, and the hat, of beaver or felt, was broad-brimmed (see fig. 45). The ordinary costume was alike excellent for its beauty and hygienic quality, neither too loose nor yet too tight, it gave warmth with ventilation, and in no way hurt the body by undue pressure. Defects were only to be found in the somewhat effeminate mode of decoration employed, as by the wearing of large lace collars, rich silks, satins, and velvets over-elaborated by the trimmings of lace, ribbon, embroidery, braids and

* Portraits often show men in full armour long after plate had been abandoned in practice.

points, not to speak of the curious wide-topped boots turned down and choked with lace, the short cloak worn on one shoulder, the plume of feathers in the hat, or the rapier belt or sash worn bandolier fashion. There was yet added to this effemination of dress another feature still more womanish, for the hair was worn long and even sometimes powdered. The opposite extreme—at first purely out of opposition—was adopted by a large section of the English people. The Roundhead (so called because he cut his hair close) eschewed lace and other ornamental accessories, wore his linen plain, had his suit of clothes made of grey or brown cloth, adopted a hat more decidedly chimney-pot in form than that now in vogue, and most illogically regarded all bright and joyous colour as the invention of the Prince of Darkness. Women, soon after 1615, grew weary of the excessively tight, pointed bodice and unwieldy farthingale. Accordingly, we find that, like the men, they adopted a looser, more comfortable style. Cambric and lace were freely used, the bodice was still laced reasonably tight, the sleeves usually worn full and gathered in at elbows and wrists, but the kirtle, as in the preceding century, was often rendered visible by wearing the gown open in front. The women of the Roundhead party in England wore, however, dresses of great simplicity, avoided lace and ornaments generally, but did not, nevertheless, fail here and there to look very charming, with neat white collar and cuff, closely fitting bodice, and reasonable heel. While in England and France bright colours were worn by ladies and gentlemen alike, in opposition to the grey and drab of the commonality, in Spain the exact opposite held good, black still being worn by the Court and bright colours by the people. In Catholic Spain, too, the dress was much more severe in cut, freer from trimmings, and nearer that of the Puritans in England than that of the Cavaliers.

In the third quarter of the 17th century, the costume of Europe which had promised so well from its new departure, the costume we see painted by the great masters of the

Spanish, Flemish, Dutch and German schools, completely broke down. To begin with, the Court of Louis XIV., without any such necessity or intention as animated the Ancient Egyptian, revived the use of false hair, and the wig (*periwig*, *perruque*, or as the Italians named it *perruca*) was forthwith started on its miserable course, lingering on the heads of bishops within our memory, and finally driven to its present shelter on the pates of royal coachmen and a few other royal and legal functionaries. Neckties, neck cloths, or cravats, the ends hanging loosely and deeply bordered with lace, began to take the place of the collar; petticoat breeches (worn long afterwards by seamen) became fashionable; the doublet was at first like a jacket, but the long, loose form soon followed with sleeves turned back, giving the appearance of huge cuffs; the waistcoat was made without sleeves, but long, and looking extremely like a second coat, and the fabrics were not merely rich but ostentatiously showy. European dress at this time was more than ever subject to a dual control; the one kind governed by the Courts with *le Grand Monarque* at their head, the other dictated by the people. Both were perhaps equally worthy of condemnation; the one for its unbridled vanities and unhealthy exposure, the other for its cast-iron rigidity and pretentious plainness. The ladies of the Court wore dresses with short sleeves, exceedingly *décolleté*, without ruffs, collars, or stomachers. Many of them exhibited a weak tendency towards a classic character, but failed completely to secure anything of classic beauty.

Hitherto the chief influences in the fashion of dress have proceeded from the highest class in those nations which have possessed the chief power; but before the commencement of the 18th century we can perceive the beginning of that general levelling down in matters of dress as in everything else, which after a century of resistance swept away every vestige of colour and ornament from all male attire, and resuscitated the trouser from its Keltic grave. In the last quarter of the 17th century the petticoat-breeches of the men and the general looseness of the women's attire

gave place to a tight trim mode, more or less a revival of the old fashions of 1636–1640. The breeches, cut with less material, were tied beneath the knee, and the stockings drawn over them; the sleeve of the coat began to be lengthened; the broad brim of the low-crowned hat was often worn turned or cocked up on two sides, while towards the close of the century it first appears turned up on three sides, and assuming the equilateral-triangular form, which, under various minor modifications, was as much the hat of the 18th century as the "chimney pot" is the hat of the 19th. The ladies began to exhibit a stiffness and formality in their attire, which eventuated in a style nearly as ill adapted to the human figure as that which was fashionable in England during the later years of the 16th and early years of the 17th centuries. We see revived the hard inflexible bodice and the close fitting sleeve, now decorated man-fashion with a cuff above the elbow, such elegance and softening as were possible being obtained by a lavish use of lace in the shape of ruffles, pinners, and top-knots (see figs. 47 and 48).

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The 18TH CENTURY began with dresses very little removed from those which marked the close of the preceding century, except that the coat-skirt, instead of hanging straight or vertically, had a little spring or stiffening given it by wire or buckram; the sword-belt was omitted, and the three-cornered hat was made smaller. Broadly speaking, there was no great change in man's dress during the 18th century, until towards the close. Little alterations were constantly being made, but the hat, the breeches, the coloured stockings, the square-toed buckled shoes, the square-cut heavy-cuffed collarless coat with its numerous buttons and braids, the long-flap waistcoat, the frilled wristband and the wig, have it much their own way until disturbed by a revolution which destroyed in its mad excitement the wheat with the tares (see fig. 49). The wig was reduced in size twice during the century, about 1720 and 1763; and these again were fashioned variously.

But before the middle of the century young men were occasionally found wearing their own hair artificially got up like the wig. The hat which had been made at first (in France) of smaller proportions grew larger (in Germany), breeches were buckled or buttoned over the stocking, and pigtails appeared. In the ladies' dress, the gradated hooped petticoat of 1710 had expanded before the year 1740 into farthingale proportions, stays were laced tighter than ever, and as a set off, the loose and somewhat graceful *saque* (of the last century) was adopted (see fig. 50). In riding habits the male costume was closely imitated, even to the wig, as early as 1710. The high head-dresses of the beginning of the century were given up for small frilled mob caps, hoods or *capuchins*, little bonnets and large hats. The feather fan of the 16th century was now superseded by the closed fan, a revival, in semi-circular form, of the Byzantine flabellum; and aprons occupy a good share of attention. But I am again warned that I have no room to treat of the many interesting and curious details that contributed to the completion of the full dress of 1700–1750.

From 1750 to 1780, and with many till ten years later, the fashion of man's dress in Western Europe changed but little; but there appeared before 1762 a short waistcoat and a coat with a little collar to the neck, the body cut with closer fit, and the buttons ceasing at the waist—a coat that was destined with slight modifications to survive for more than a century as the ordinary frock coat of modern times. The coat it superseded was in every way superior to it. If the weather were cold or rainy, you could button it down to the bottom of its skirt, and so obtain warmth and protection; while in appearance, though not quite so becoming as the longer coat of 1680, it was nevertheless perhaps better adapted for general wear, and combined the two qualities of tightness and looseness, the one for cold, the other for warm weather, necessary for dress under such a climate as that of North-Western Europe. From 1770 to 1790 the changes in the women's apparel, especially in the

matter of head-dress, were far too many even to catalogue in these pages. Where the influence of certain æsthetic people could be felt, the costume of the hour was so modified that it has for us, in many cases, a quite distinct charm. The Queen Marie Antoinette exercised a very beneficial influence on the fashions in France, moderating and refining them as Sir Joshua Reynolds is said to have done in England. America preserved a dignified simplicity, and her influence was beginning to react on European folly and extravagance. For some few years before 1760 dress generally had been sobering down, but about that time the passion for ornamental accessories revived, and many very beautiful examples of embroidery on coat and waistcoat were the result. By 1766 the corners of the coat skirts, as worn by the French military, were turned back and fastened under the pocket flap; then the skirt itself was gradually sloped and cut away, and thus the dress-coat of the 19th century was clearly foreshadowed.

For three years before the fall of the French monarchy, that is to say in 1789, the people once again took the fashion of dress into their own hands, and curious incongruities, strange fantasies, evidences of an unsettled condition of things, began to be made manifest. As early as 1788 women freely adopted much of the character of the male attire, carried walking-sticks or switches, and even wore low heels to their shoes. Men became grave, not to say sad, in all questions relating to the subject of their wardrobes. They assumed plain black and left off powder. Steel and glass took the place of diamonds and gold for buttons and trimmings; the wig was gradually losing ground, the tall or chimney-pot hat of the English Roundheads was revived, the collar of the coat was raised and otherwise developed, the cuff almost disappeared, the open waistcoat became general, and frilled shirt-fronts were to be seen. As early as 1790 English sailors appeared in loose trousers, old-fashioned and solemn-going people still wore breeches, but young swells were now and then met in tight pantaloons. A long great-coat with three or more

capes was introduced into general winter wear about this time, and also a round hat very like the modern *bowler*, only with wide brim.

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Between 1796 and 1799, the man's dress was revolutionised, and the wardrobe for the 19TH CENTURY was tolerably complete. Twenty years ago, and possibly later, a few English country gentlemen dressed in all respects the same as an *élégant à la mode* of 1789, even to his watch and his whiskers. It is only when we turn to the other sex that we find costumes as marvellous in their number and variety as in their absurdity. The silly attempt made in France to revive the names and forms used in the days of the old Roman Republic included in its programme tunics, sandals, and other articles used by the Roman matrons. These were, however, grossly caricatured by the dressmakers in the process of translation. Accidental and momentary revelations were turned into permanent exposures, the girdle was lifted until it occupied externally the place the mammillare held of old under the dress, and the skirt was made to cling to the form in a way that would have shocked a real Roman citizeness, not for any suggestion of the beauty of human form it might have conveyed, but for the strange developments it accentuated, and the curious contours it emphasised. For we may be quite sure of this, that the lighter forms of classic dress can never be appropriately worn by bodies which have been made to grow under conditions wholly at variance with those under which the Greek and Roman flourished. The natural body (or classically-grown body, for they are both the same) is in its highest development the monarch or master of its dress, and is free to do pretty much what it likes with it; throw the knees out of place by two or three centuries of high heels, throw the hips and other things out of gear by hard non-elastic pressure over the ribs, and you lose your throne, you become the slave of dress, you no longer govern your clothes, your clothes must govern you. The women of the Empire (see figs. 56, 57, 58, 59, 60) were

the outcome of generations of stay-imprisoned bodies, and their gait and postures showed how hopeless it was to expect that they were fit to enjoy that freedom of reasonable attire which was the long inheritance of the great civilisations of Greece and Rome. To leave off stays and high heels all at once is as unwise as absurd, and as hopelessly impracticable as any suddenly applied violent remedy for any other deeply rooted, long-engendered habit. This truth, as I hold it to be, was not felt for some time, and the long farewell to "classic" modes did not take place until the 19th century was well advanced.

Between 1825 and 1850 there was little change in the gentleman's dress. His hat, instead of sloping inwards and upwards like Dutch chimney-pots, turned outwards like Venetian ones, the brim became very curly, and the masher's hat of 1883–1884 is not far removed in shape from the old gentleman's hat of 1842. Except among seafaring folk, tightness was still a characteristic of the trouser, which was carefully strapped under the boot. The collar of the coat, reduced in height, fell more on the shoulders, and the cut-away or dress coat was no longer used for morning or walking wear, except by old-fashioned people or on occasions of ceremony. The Quaker did not change the collarless cut-away coat of the last century; but even he adopted a "chimney-pot," which, however, was of a more pleasing shape than the fashionable hat, being cut low in the crown and broad in the brim. The waistcoats were cut low, and the open space absurdly enough filled up again by a loose arrangement of the long ends of the high cravat or stock, which imprisoned the whole neck in a most unhealthy fashion, some cravats being exceptionally hard and stiff, while others were bound round the neck more like mummy cloths.

The ladies' dress in north-western Europe during the second quarter of this century was singularly lacking in grace. Things called bustles (what we should now call dress-improvers) gave to the plain or flounced skirt a certain amount of bell shape, bodices were screwed in

tighter than ever, and the shawl was worn in a way that seemed to indicate a complete unconsciousness of the beautiful possibilities of drapery. Very different was the state dress of Amelia, Queen of Greece (1844), in itself the most elegant European costume then extant, but too heavy, and giving the impression of too much warmth for the climate of Athens.

Of the dresses worn since 1850, of the few distinctive forms such as the *crinoline* and the *princess*, of the many varieties, good and bad, which every month brought forth, of the multitude of trimmings appropriate and monstrous, of the new sickly tones of colour or the atrocious aniline dyes, of the masher's collar, the pointed-toed boot, the divided skirt, and the more or less accurate revivals from the wardrobes of the last three centuries, I can but venture on a passing judgment that, taking the evil with the good, the period of 1873–1883 has given us dresses (for both women and men) where beauty and health have had more chance of flourishing than at any other time since 1640. It is true, no doubt, and one might easily have foreseen it, that the princess dress has been tightened to the last degree of folly; it is true that heels were never *generally* worn so dangerously high, that full dress has never been so near undress, or lace so inappropriately and inharmoniously handled; still, these are defects belonging to the *modus exaggeratus* to which the best of fashions seems exposed. There is still present with us the closely-fitting bodice that has endured with but I think only one interruption for more than five centuries. Women still wear stays to make their bodies "gent and small," like that of the carpenter's wife in Chaucer; but they are not all quite such prisons as in days gone by. The higher education of women is beginning to influence this long-enduring badge of their patient sufferance; and the increased knowledge, and thereby of necessity appreciation of old Hellenic culture may perchance, before very long, reduce the corset to the mammillare. One thing, however, is quite clear; that in the climates of transpontine Europe the old classic dress cannot be revived. Indeed, except on a substratum warm

and reasonably tight fitting, such as is provided by the bifurcated garment known as *combinations*, the characteristic beauties of classic dress cannot be realised. Even then it is doubtful whether its endurance would be for long; the 13th-century folk tried it, but gave it up in favour of a reasonably tight mode, which, as I pointed out at the beginning, is the one dictated by such a climate as that of North-Western Europe. The men of Italy in the time of Dante were probably as rationally dressed as any before or since; for although the external garment hung loosely, the under dress was composed of tight hose and jupon—*Anglice*, pants and jacket. Women might, and do, borrow from men many less appropriate fashions. But when I use the words *tight*, or *reasonably tight*, it should be understood that I mean these words to be taken only in their relative sense as opposed to the flowing looseness of a Greek chiton or a 13th-century tunic. Your really tight-fitting garment, unless very elastic and open in the web, is neither warm nor healthy, and cold extremities are nothing like so dependent on the lightness or thinness as on the tightness and texture of their covering; tightness, that is, which reaches a degree where the free circulation of the blood is impeded. Nor is looseness any more to be desired than excessive tightness. In such climates as those of London, Paris, Berlin, Copenhagen, or New York, loose attire compels the multiplication of garments, and a quite unnecessary expenditure on fur, an extravagance to which the people of the 15th and 16th century were to some extent driven by the loose open plan adopted in the cut of their clothing. Close, but not too tight in fit, the undermost garment, either in one or two divisions, should cover the body from neck to knee, or even to heel, with sleeves or half-sleeves; but it would be worse than useless if made of other material than pure wool, which, we cannot too often insist, is superior to all other textiles as a non-conductor of heat, and absorber and distributor of moisture. Thus, in cold weather, preventing the heat of the body but not its exhalations going out, and, in hot weather, the heat of the atmosphere coming in. But the advocates of the

woollen system of clothing insist further that *all* the apparel, where possible, should be made of pure wool, and I am strongly inclined to believe that they are right. The Assyrian, and the Greek, wore, as a rule, very few articles of clothing, and those of woollen fabrics, fine, open, gauze-like in structure, or thick, loosely made and fleecy: and as the best features of modern civilization have descended to us from these ancient peoples, we might do well to imitate them in our choice of dress materials. Next to pure undyed woollen goods follows natural, or undressed leather; and next to that I am inclined to place spun or raw silk, if woven with sufficient looseness or porousness, for unquestionably silk is so far like wool, that it has an electrically beneficial influence on the skin. The defect in most silks, as in most linens and cottons, consists in their being too closely woven, and thus preventing the due ventilation of the sartorial habitations constructed of them. Cotton, though inferior to wool, is superior to linen as a non-conductor; but it is a very poor absorbent, while linen is a rapid conductor, attracts moisture, and has a very low radiating power. Then, again, colour should be considered, and that not merely from the artist's point of view in laying down rules for reasonable dress. For instance, every one knows that white is the best protector against heat; but it is not so generally known that the relation which other colours bear to white, in this respect, is in the following order:—light gray, yellow, light red, or pink, blue, and black. Lastly, whatever wisdom we may display in our selection of material and colour, healthy or hygienic dress will not be possible until it has at least as much beauty of form and cut to recommend it as that which may be seen on most lawn-tennis grounds. And, thus, I have come round to the proposition with which I started, that health without beauty was after all a mere compromise with disease. To those who having eyes, yet do not see, my words are useless; to those who see, I would say there can be no such thing as the possibility of that contentment which is at the basis of all true health until you get rid of

the ugly in life, including those inharmonious lines and colours which constitute the ugly in dress. In our present general state of ignorance as to what constitutes health and beauty, any contribution making for one or the other, however isolated or fractional, is to be welcomed. A well-drained house, however awkward and ill-proportioned in appearance, is a distinct gain on the awkward house that is badly drained ; and the converse is equally true, for a house of good proportions and interesting cut or shape, with inefficient drainage, is certainly health-giving to the eye, and to be preferred to an ill-conditioned looking shelter, with similarly defective sewers. So also is it with our dress. A costume calculated to increase the functional powers of the body, to perfect the action of the skin, and restore to flesh its natural elasticity and firmness, although it may be as awkward in appearance as the conventional frock-coat and trousers, must undoubtedly be an immense gain. And on the other hand, a beautiful dress, although deficient in its obedience to sanitary laws, is none the less to be recognised as serving a good and healthy purpose, compared with the thousands of dresses that are in no way beautiful, and are equally disobedient. The evil inseparable from all these isolated views of health and beauty is that the advocate of either one or the other as he deepens his groove, narrows it ; and so your sanitary authority, if he does not openly despise the beautiful, has a smile which is akin to a sneer always ready for it ; while your " person of taste " coolly ignores every law—sanitary or other—if it interferes for a moment with the fad or fancy which is far too often supposed to be concurrent with art. Anything therefore tending to widen the grooves in which these two classes run, to widen them more and more until they meet in one broad working, where everything that is healthy shall be beautiful, and every beauty shall be healthy, cannot but be for the good of humanity.

FERMENTATION.

BY

DR. DUCLAUX,
OF PARIS.

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FERMENTATION.

LECTURE I.

THE PART PLAYED BY FERMENTS IN THE WORLD.

Summary—Alcoholic fermentation—History—Liebig's theory—Pasteur's theory—Functions of ferments—They complete death and prepare life—Their intervention in diseases—What is conveyed by the word *ferment*—*Bacillus anthracis.*

FROM time immemorial, brewers have been familiar with the art of preparing, by means of malted barley, a mucilaginous liquor, both insipid and sweet in taste, known as the "wort" of beer. This preparation, or "wort," if left alone, soon putrefies. It becomes muddy, covered with a floating film, emits a disagreeable smell, which increases in intensity, and assumes an offensive flavour. All this takes place very rapidly, and in three or four days' time this would become a horrible drink. Experience, however, has shown how, on the contrary, it can be made into excellent beer, by the addition of a little yeast, the remains of a previous operation, which the brewer always finds in abundance in the receptacles whence he has drawn new ale. Under the influence of this yeast, an internal working occurs in the mass, gas is disengaged, producing a sort of effervescence, the sweet taste disappears, and is replaced by another, a taste dear to man in all ages and in all places. Osiris, Bacchus, Noah, personify and symbolise the gratitude of the human race to the inventor of alcoholic drinks.

But if the *practice* of the operation is old, its *science* is relatively modern, and is the outcome of a series of discoveries. Sugar disappears during fermentation. That

was what was first observed; but what takes its place? That was what remained unknown for centuries. We had to wait for the expansion of Arab civilisation in order to learn to know alcohol, that essential term of the transformation of sugar. We had to wait still longer—until the latter half of the eighteenth century—before learning from the Scotchman, Black, that the gas disengaged during fermentation is solely carbonic acid.

To these discoveries Lavoisier, in 1788, added another, which threw on the question of fermentation an instantaneous and lasting light. According to him, carbonic acid and alcohol are the only products of the transformation of sugar, and are formed in pretty nearly equal quantities. 100 grammes of sugar, the number which we shall always take as the basis of our valuations, give nearly 50 grammes of alcohol, and 50 grammes of gas. It is really a case of halving.

That is not all. Sugar contains carbon, hydrogen and oxygen; so does alcohol, but in other proportions. In carbonic acid there is only carbon and oxygen. The decomposition of sugar is therefore accompanied by a complete breaking up. The simple elements of that body are re-arranged differently. Part of the carbon, a third, and a large portion of the oxygen, two-thirds, unite to form the carbonic acid. The remaining two-thirds of the carbon, the whole of the hydrogen, and a third of the oxygen, form alcohol. The breaking up of the primitive molecule of sugar amounts, therefore, to the production of two new bodies, one containing more oxygen than sugar, more burnt and incapable of undergoing a fresh combustion, carbonic acid, identical with that which escapes from our stoves; the other, still combustible, as sugar used to be, capable like sugar, of giving heat, and of becoming a means of nourishment, alcohol. We shall soon see what there is to modify in this statement.

But there is another fact, which Lavoisier passed by, and the importance of which has since increased to the extent of creating a new science, and of opening to industry, to

medicine, to the social life of man, the newest and the most unexpected horizon. What is this yeast which has to be mixed with the wort of beer, to prevent the latter from putrefying? Without it, fermentation is impossible, and yet it plays no part in Lavoisier's explanation. He does not even mention it.

It is, as we have seen, the remains of a preceding operation. It is found, in the form of foam at the top, or of deposit at the bottom, of recently fermented liquors. In appearance, it is a yellowish pulp, which, when filtered, separates into a clear liquid, and a soft, plastic substance, like clay, only rather more adhesive. This substance increases in weight during fermentation, and the brewer, on an average, takes out five or six times more than he put in. This was all that was known about it at the beginning of this century.

Yet in 1680, Leuwenhoeck, observing it with the microscope,—then a recent invention—saw that it was formed, as shown on the left side of Figure 1, of an infinity of ovoid globules, more or less elongated, but very small, the longest being hardly more than one-hundredth of a millimetre. The homogeneity of form of these globules, their equal size, their organized aspect, the fact that they multiplied during the fermentation, ought, since Leuwenhoeck, to have entitled them to be considered as living organisms. But the mind of man is so constituted that he does not go naturally to the truth. All he can do—and that is saying a good deal—is to come back to it, when, after wandering about in the paths of error, he finds they have no outlet.

Such is the case in regard to yeast. Leuwenhoeck's observation failed to be understood for more than a century, and was almost forgotten, when, in 1825, Cagniard-Latour in France, and Schwann in Germany, renewed it, with an invaluable addition. In following, with the microscope, the transformations of the yeast added to the beer-wort, they saw what has been sought to be shown on the right side of Figure 1. On each of the globules we have described appeared and grew a small bud, which soon attained the

size of the parent globule. Then, in each of these two globules, the same process took place ; so that, by degrees, the liquid ended by being peopled by an infinity of globules of different generations, the offspring of each other. This explains the increase in the quantity of the yeast observed at the brewer's. Moreover, to this *fact* of observation, Cagniard-Latour had had the merit of adding an *idea*.

Fig. 1.

He had formally stated that if yeast makes sugar ferment, it is no doubt "through some effect of its vegetation and of its life."

Such is the origin of one of the most productive theories of the 19th century. Its growth, however, was laborious; and it should be said, in justice to the con-

temporaries of Cagniard-Latour, that that savant's theory made but a poor struggle against doubt. Its only foundation was the round shape of the globules, and their budding. But an illustrious microscopist, the German Ehrenberg, had precisely shown that many mineral and organic substances could, by forming and depositing themselves in a liquid, take the shape of ovoid globules. There remained the question of the budding. But might not that be an error of observation, resulting from the accidental proximity, under the microscope, of a large globule and a small one? Indeed, how was one to believe in the living character of the agent of alcoholic fermentation, when one found neither yeast, or anything similar, in a number of other phenomena whose analogy to the fermentation of sugar could not be contested? The leavening of a mass of dough or paste, the swelling produced by the introduction of some leaven from a preceding operation, were these not the exact image of the phenomena presented by beer? Was it not natural also to connect this question with the property which a drop of sour broth, or sour milk, has of producing in a quantity of broth or milk alterations identical with those of which it is the seat? As a matter of fact, in all these cases, there is nothing to be found which is analogous to yeast. Nor is there any yeast in putrefying wort. On the other hand, all these phenomena, evidently influenced by one common law, have one characteristic in common, and that is that they all occur in the presence and under the influence of a small quantity of organic matter in the course of decomposition. That is their necessary leaven. The yeast of beer, notwithstanding its organised appearance, has no other character; and if it causes the destruction of the sugar, it is because it is itself in course of destruction. In other words, instead of living and developing, according to Cagniard-Latour's theory, it only putrefies, and causes, together with the decomposition of the sugar into alcohol and carbonic acid, a deposit of the organic matter of the wort under the same form as its own.

This theory, so seductive in appearance, bears the great name of Liebig. The only commendation that can be granted to it is that it only gave way to a theory bearing a still greater name, that of Pasteur. A single well-conducted experiment was sufficient to enable this savant to upset Liebig's theory, to give to Cagniard-Latour's idea the experimental authority which it required, and to impel science on the fruitful course which it is now following. The experiment is as follows:—

In a medium entirely freed from that organic matter to which Liebig assigns the most important part, only containing sugar, a salt of ammonia intended to furnish nitrogen, and suitably selected mineral elements, a few milligrammes of yeast are introduced as seed, and a regular fermentation is seen to take place, with the ordinary characteristics. Carbonic gas is disengaged, and the sugar disappears, leaving in its place a perfectly pure alcohol.* Meanwhile, the yeast, instead of being destroyed and putrefying, as laid down in Liebig's theory, buds and multiplies, and twenty, a hundred, a thousand times more is taken out than was put in; for theoretically and practically, a few globules, not weighing a tenth of a milligramme are sufficient to produce fermentation, and more than a gramme of yeast may be obtained by fermenting 100 grammes of sugar. Cagniard-Latour was therefore right, and if we do not as yet quite understand the obscure mechanism by which the life of yeast is related to the fermentation of sugar, we have the right to assert that the two facts are connected, seeing that the first does not occur without the second, nor the second without the first.

It is both an attractive and an irritating characteristic of Science that one step forward should prepare and invite

* One of these fermentations, made in a purely mineral medium forms part of the objects from M. Pasteur's laboratory which are at the Health Exhibition. The old labels, which have been left, prove that this example is ten years old. The appearance of the liquid, and its clearness, show that it has remained pure.

another. One of the details of the preceding experiment furnishes matter for reflection. We have seen that the weight of yeast produced represents about one per cent. of the weight of the sugar. This yeast is a living organism, and has all the complexity of composition of living organisms. It contains: mineral matter, including phosphorous and sulphur, selected from the mixture of salts: nitrogenous matter, the elements of which have been drawn partly from the sugar, partly from the ammonia salt; finally, carbo-hydrates, of which all the elements proceed from the sugar. Thus it is from the sugar that it has derived nearly all the material of its tissues, and what it has thus derived can evidently not have undergone alcoholic fermentation. A fraction of this sugar, which we may roughly put down as one per cent. of the total weight, therefore gives neither alcohol nor carbonic acid. It furnishes yeast.

The results obtained by Lavoisier cannot therefore be correct, and indeed M. Pasteur has shown that they were much less so than one might have thought. For carbonic acid and alcohol are not, contrary to what was believed before him, the *sole* products of alcoholic fermentation. A little over three per cent. of sugar gives glycerine, a little less than one per cent. gives succinic acid. Thus five per cent. of sugar escapes the decomposition into nearly equal parts of alcohol and carbonic acid, to which the remaining 95 per cent. of sugar are alone subjected, when the fermentation takes place under ordinary conditions. And now this phenomenon ceases to present the simple aspect which it appeared to us to have at first, and which we so naturally connected with the simplicity of its cause. There can no longer be question of a simple chemical splitting up of the molecule of sugar. At the expense of the latter, we see the yeast forming varied tissues, nitrogenous matter, cellulose, fatty matter. At the same time, the sugar undergoes the most varied transformations; it becomes carbonic acid, alcohol, glycerine, succinic acid, furnishes, in smaller proportions, other bodies which I

could mention,* and others again which Science has not yet learnt how to isolate, because there is no branch of chemistry more difficult than that which deals with living organisms. In the place of the chemical problem which Lavoisier seemed to have solved, arises a physiological problem, more intricate, more delicate to handle, but also vaster and richer in consequences.

Of these, there is one that we must notice at once, and the importance of which must detain us for a while. Let us return to the wort we spoke of at the beginning. Let us abstain from putting in any yeast, and, in order to guard against the changes to which we know it to be so easily subject, let it boil for a few minutes. Then, let it cool in a carefully closed vessel. What will become of the wort, thus preserved?

The question seems easy to answer. This, however, is far from being the case, seeing that it has formed the subject of an enquiry which has lasted two centuries, and in which illustrious savants of all nations have taken part. Italy is represented by Redi and Spallanzani, England by Needham and Tyndall, Holland by Swammerdam, Germany by Schwann, Schulze, Helmholtz and Liebig, France by Buffon, Lavoisier, Gay-Lussac, and Pasteur. The solution which the last-mentioned savant has given of the question, a solution which must be accepted by anyone capable of understanding the value of a proof, enables us to assert that the wort thus preserved will keep indefinitely its original properties. Ten, twenty years after, it will be found just as it was left.† If any air remained in the flask, this air

* Such, for instance, as pure acetic acid, a sample of which, proceeding from 100 litres of wine, which have undergone a regular process of fermentation, will be found exhibited in the contributions from M. Pasteur's laboratory.

† This can be seen at the Exhibition, by the flasks which M. Pasteur opened in 1860, in his celebrated experiments on the "Mer-de-Glace," at Chamounix, and which he filled with pure air. M. Pasteur's contribution to the Exhibition is an historical summary of the works proceeding from his laboratory, beginning with his researches on molecular dissymmetry, whence resulted his studies of ferments.

will only have lost traces of oxygen, replaced by a nearly equivalent volume of carbonic acid. In other terms, there will only have been an insignificant combustion of the components of the wort, indicated by a slight change in its taste. But as to the sugar, the nitrogenous matter, and the other elements of this complex liquid, time will have spared them. Under the conditions in which we have placed them, they are unchangeable, and, so to speak, eternal.

This is not the case with the wort fertilized with yeast, or left to the mercy of the microscopic species. The sugar disappears, gases are disengaged, carrying into the air under the form of carbonic acid, of hydrogen, a part of the organic matter of the liquid. If regular fermentation has taken place, the alcohol serves as a temporary protection to the beer, but if it is kept too long it gets covered with moulds, whose function is to use up the alcohol. When the latter has disappeared, the liquid gets worse and worse, various moulds appear on its surface, destroying and vaporizing all they meet in the way of organic matter, and in a few weeks, often in a few days, under favourable conditions, instead of the 80 grammes of various substances contained in a litre of Burton ale, only a few centigrammes of detritus will be found.

Such is the action of yeast and the other microbes which beer has sustained, simultaneously or successively. They have destroyed, i.e. brought back to the simple forms of water, carbonic acid, hydrogen, and ammonia, all the organic matter that came within their reach.

And this is a fact that is not special to wort. Whenever and wherever there is a decomposition of organic matter, whether it be the case of an herb or an oak, of a worm or a whale, the work is exclusively done by infinitely small organisms. They are the important, almost the only, agents of universal hygiene; they clear away, more quickly than the dogs of Constantinople, or the wild beasts of the desert, the remains of all that has had life. They protect the living against the dead. They do more. If there are still living beings, if, since the hundreds of centuries the world

has been inhabited, life continues to be equally easy and plentiful, it is to them that we owe it.

A moment's reflection will be enough to show us that life, whether it be that of the higher plants, or of animals who live on vegetable matter, is nothing else but the working, the organizing of the gases taken from the atmosphere, or of the nitrogenous and saline substances existing in a state of dissolution in water. It is possible, by means of air, and the gaseous elements it contains, by means of water, and the elements contained in rain, to create and develop the largest oak, whose organic mass would exceed by many hundred times that which might originally have existed, ready made, in the portion of earth in which it took root. An oak, a blade of grass, an animal that eats grass, a carnivorous animal that has eaten an herbivorous one, were originally water, carbonic acid, salts of ammonia, and soluble mineral substances. But once produced, this organic matter becomes tangible, and insoluble in water; it is paralysed, incapable of contributing to the nourishment of a new vegetable life; and if it were to remain perpetually in this state, if its elements were never to re-enter the general order of things, into the atmospheric or aqueous circulation of the globe, the atmosphere would soon be deprived of its elements of organism, water of its nutritious matter, and life would become impossible on the surface of the globe.

If, therefore, the atmosphere and water regain perpetually that which the living world incessantly takes from them, if they preserve their composition and their productive qualities, if, consequently, it is possible for fresh generations to succeed each other, inheriting not only the form, but the matter of previous generations, it is because, in juxtaposition to the world of beings with which we are most familiar, there exists a world of minute creatures, which we are barely beginning to know. We saw, just now, what great factors they were in public hygiene. We now see in them the indispensable agents of the maintenance of life. They are very small, you will say, for such a duty. The

remark is natural, and it will give us an opportunity of setting forth one of the most curious peculiarities of the history of these minute beings, that which we must accustom ourselves to see contained in the expression " Ferments." We have seen that their function is to destroy organic matter. But the larger animals also destroy organic matter, for their food. This is the difference. A man consumes daily a quantity of food equal to one-fiftieth ($\frac{1}{50}$) of his weight. The yeast of beer can break up, daily, from four to five times its weight of sugar; and it is not the most powerful ferment. The organism that governs the acetification of beer can remove, in one day, from 50 to 100 times its weight of alcohol, and many others are equal or superior in power.

We shall soon see what are the reasons for this singular difference in the specific activity of the microbes and the higher animals. Let us accept it at present as a fact. It shows how ferments can accomplish the arduous duty allotted to them; it also shows how, notwithstanding the importance of the part they play, they have remained so long unknown, or misunderstood. Their infinite smallness is balanced by their prodigious activity. Hence, there is, in the study we are about to make, a special character, somewhat strange at times, and which the mind has some difficulty in getting accustomed to, but yet which it is necessary to fully master, unless we wish to proceed, blindfold, through this world of infinitely small organisms, so fertile in discoveries.

A curious, and final, example will illustrate what may be expected of the idea of ferment in the study of the phenomena of life, and will reveal another side, not less interesting, of the part played by microbes in the general economy of the world.

One of the most deadly of the diseases incidental to live stock, is that known, when speaking of sheep and of cattle, by the name of splenic fever; and in the case of man, as malignant pustule. Apart from the losses which it occasions, and which amount yearly to millions, one

is impressed by the suddenness of its appearance, and the rapidity of its progress. Barely a few days, often a few hours, intervene between the first indication of illness and the death of the animal.

In 1851, two French medical men, Messrs. Rayer and Davaine, while microscopically examining the blood of animals which had died of this disease, had observed the

Fig. 2.

existence of the small filiform, stiff and motionless bodies, represented to the right of Figure 2, mingled with the normal blood corpuscles. They were of minute width, from two to three thousandths of a millimetre, and their length barely exceeded that of the diameter of a corpuscle. Messrs. Rayer and Davaine noted their existence, but did not give them any further attention.

In Germany, Pollender, in 1857, and Brauell, in 1857, resumed and extended this observation, but without arriving at any other result than to establish a mysterious connection between splenic fever and the development of the rod or germ of bacteridæ. As to seeing between the two phenomena, what seems so natural to us to see at present, viz., a relation of cause to effect; as to admitting that, between a powerful and resisting organism like that of the ox, and an almost invisible organism, there could possibly be a struggle in which the latter prevailed over the former, this would have required either a moral audacity rare among savants, whom experience teaches to be prudent in their deductions, or a still rarer genius of intuition. Science was not ripe for such an hypothesis, and still less for its justification.

But in 1861, M. Pasteur demonstrated that the agent in the breaking up of the acid of sour milk, lactic acid, into the acid of rancid butter, or butyric acid, is a very minute rod or germ, the form and dimensions of which are entirely comparable with those of the bacteridæ of Davaine. Notwithstanding its smallness, it is very active, and will ferment, in a few days, large quantities of matter. From this moment, the way was cleared. M. Davaine, strongly impressed with the truth of the thing, at once returned boldly to his observation of 1851; and since it was allowable, henceforth, to attribute to these infinitely small agents, effects apparently out of proportion to the causes, the question occurred to him whether the morbific agent of splenic fever—which transmits the disease from one animal to another—might not be these same bacteridæ, he had formerly discovered with M. Rayer. This chain of ideas is not an hypothesis. It was admitted from the first by M. Davaine, whose sincerity therefore equalled his scientific perspicacity.

From this work of Davaine dates the admirable scientific movement which we are now witnessing. This movement was a slow and laborious one at first. Adherents had to be won over by the accumulation of incontestable facts and the

only means at hand were the feeble methods of a science in its infancy. It is again to M. Pasteur that is due the merit of impelling it on the certain course which it now pursues, by his work, in 1878, on the Bacteridæ of Splenic fever or *Bacillus anthracis*.

This, it will be seen, is only six years ago. At that time, notwithstanding Davaine's works, and the numerous attempts made in Germany, notwithstanding even M. Pasteur's classical investigation of the diseases of the silk-worm, it might have been asked, were there really diseases due to the action of these microbes? And, now, we may fairly ask, are there really diseases in which they do *not* intervene? Thus their functions extend beyond anything that could have been foreseen. We have seen them working the destruction of dead matter, the disappearance of organisms which life has forsaken; now, we see them taking possession of living organisms, sometimes producing rapid death, sometimes only local disorders; in other cases, when they are not strong enough to fight and conquer, waiting till some external circumstance, a loss of blood, or a chill, shall weaken the animal in which they are implanted, and shall make their prey easier to seize.

In this double part of theirs, when they are working for us as when they are working against us, they are the same; they endeavour to satisfy the same physiological requirements; they display the same double characteristic of infinite exiguity in apparent means, and of powerful destructive energy in results. To study ferments and the laws of fermentation is, therefore, as it were, to study the laws of health and disease. It also means, as we have already remarked, the study of hygiene. This explains the appearance of this little book, among the more special and practical treatises which have been published at the initiative of the organizers of the Health Exhibition. They were quite right in wishing for a summary of the History of Ferments. I only wish I was as sure they were right in asking me for it.

LECTURE II.

FORMS OF EVOLUTION AND DISTRIBUTION OF MICROBES.

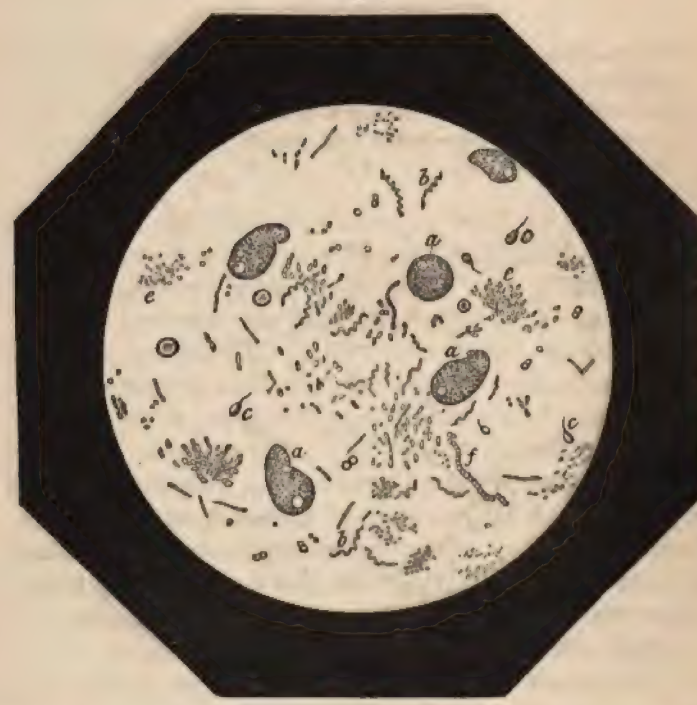
Summary—Principal forms—Micrococci—Bacilli—Yeasts and Mycoderma—Formation of spores—Their resistance to the action of air and heat—Consequences relating to the distribution of microbes in air, earth, and water—Solids and liquids deprived of germs—Fluids of the economy.

AN account of micro-organisms or microbes, even when restricted within the limits which we propose to assign to it, ought, regularly speaking, to be preceded by a classification enabling us to recognize and name the numerous species with which we shall have to deal. But Science does not possess such a classification, which it would be impossible to establish only on considerations of structure, of form, of size or of physiological functions. The structure is pretty nearly the same in the various ferments, and moreover it is very simple, a bag, closed on all sides, full of a gelatinous, transparent, and nearly always homogeneous liquid, called protoplasm. The form and the size do not supply better characteristics. It may be seen, from Fig. 10, representing the septic vibrio, how much they vary in the same species. The long threads, shown in the middle of the corpuscles of blood in one of the quadrants, are the same microbe as the numerous forms in the remainder of the figure. Finally, the physiological function, the most reliable element of classification, is still very imperfectly known to us, even in respect of the ferments which have been the most carefully studied, such as yeasts, for instance. With data so limited and so uncertain, only deceptive classifications can be made. It will be better to restrict ourselves to some

general facts concerning the microbe world, the principal groups to be met with there, and the names which it has been agreed to give to them.

The liquid where we are most likely to find, either simultaneously or successively, the various forms we are about to describe, is precisely that beer-wort we mentioned at first; if left to itself, during the heat of the summer,

Fig. 3.



after having had a little pulverised chalk added to it, and examined at the end of a few days, the gelatinous layer formed at the surface will, usually, be found to contain the complex mixture of organisms shown in Fig. 3.

We may as well at once put aside the colpoda (*a.* fig. 3.), large infusoria of complicated structure, having a mouth, stomachs, a heart, etc. These are not ferments; they live

on them. They prowl, like beasts of prey, in the liquid inhabited by smaller creatures which they devour, just as a whale does fish.

We shall also set aside, as being still imperfectly understood in respect to their functions, the Monads (*c*), rounded corpuscules, of a spherical or lenticular shape, moving about, with a rapid and tremulous motion in the drop of

Fig. 4.

water under the microscope, and propelling themselves by means of one or more hairlike cilia placed either in front or behind. But, on about the same level as to size as the monads, will be found cells—always motionless—of which the yeast, which is already familiar to us, affords the best type. All these cells multiply by budding, as in the case of yeast, and display great activity. M. Pasteur once saw two

globules increase to eight, including the parent globules, in two hours. Thus, in 24 hours, a single one could produce sixteen millions, were it not that, by their very multiplication, they end by impeding one another. Besides this mode of reproduction, there is another which is rarer, more prolonged, and less familiar.

All the organisms of this form do not make sugar ferment. Some species prefer the surface of nutritious liquids, where they form films, of a fatty aspect, generally opaque, and more or less uneven. They are usually called *Mycoderma* ; thus the moulds of wine or beer (Fig. 8), are mycoderma. As this name may be useful, we will keep to it, and reserve the name of *Yeasts* to designate the agents of the fermentation of sugar, although there exists no well defined distinctive character between the two groups, and even, as we shall see, the same species may sometimes be a Mycoderm, and sometimes a Yeast.

Beside these Yeasts, and motionless like them, may be seen smaller round globules, the diameter of which is always approximate to a thousandth of a millimetre. These globules are rarely single ; they rather go in pairs, or even in long chains or strings. These forms are the natural result of the mode of reproduction. Each of these bodies grows lengthwise at first, and then contracts in the middle. A central and transverse constriction appears on the surface, and becomes more and more marked, whilst the bodies thus divided resume their globular shape. We shall call these organisms *Micrococci.* The greatest enemies of the human species belong to this group. To Micrococci are due abscess, phlegmon, pleurisy, suppurations of all sorts, and nearly the whole of skin diseases.

Micrococci can, as a rule, readily be distinguished from rods, or germs shaped like a cylinder rounded at both ends. These germs are of very variable sizes. The smallest are sometimes termed bacteria, the largest bacilli. They multiply by transverse segmentation : each separates in the middle into two new organisms, with which the same phenomenon recurs. Sometimes these two fresh organisms

separate before multiplying, in which case the specimens are only seen singly, or in pairs, in the liquid : sometimes they remain united, and then, according to the number and distribution of the transverse segmentations, there can be obtained, with the same species, either long flexuous and tangled threads, where the separations are very rare, or chaplets of specimens hardly longer than they are wide, and resembling, except that they are more irregular, chains of Micrococci.

The length of the specimen is therefore a valueless characteristic. This also applies to its mobility; certain species are motionless at all times of their existence, such as *Bacillus anthracis*. Others are motionless when old, and only move during the first hours, or days, of their existence. Some appear to have a propeller like the Monads, others not. Some move slowly, combining rigidity with a certain degree of suppleness, and their motions are not devoid of gracefulness. Others dart like arrows, with a tremulous, and, as it were, a vibrating motion. These are more specially designated by the name of Vibrios or Vibriones, which it would be well to give up, because the characteristic which it attempts to convey is well nigh impossible to define properly. Others again, of spiral shape, proceed like a screw in its sheath. To these may be assigned the name of Spirilla.

The domain of the Bacilli is populous. It contains the active agents of various diseases, tuberculosis, splenic fever, leprosy, and more especially the agents of the most common kinds of animal and vegetable fermentation and putrefaction. This lends an interest to the modes of reproduction therein to be found.

We have seen the characters of that which proceeds from transverse segmentation. A curious calculation, of Cohn, illustrates its power. He found that it would take two hours for two living organisms proceeding from segmentation in certain Bacteria to attain the dimensions of the parent, and, in their turn, to multiply. Hence, in three days, the progeny of a single specimen, if un-

hampered, would number 4772 billions. As it is about $\frac{1}{1000}$ of a millimetre in breadth and two in length, and as its density is about the same as that of water, 536 millions would be required to make the weight of a milligramme. It is then easy to calculate that the offspring of a single specimen would, in 24 hours, only weigh $\frac{1}{50}$ of a milligramme, but that, at the end of three days, it would weigh 7500 tons. In the presence of such figures, the mind gets dazed, and it is fortunate that the intervention of the natural forces with which we shall soon become familiar prevents their becoming realities.

But however powerful this mode of multiplication may be, it is not the only one. It appertains to the young or adult animal, in course of active nutrition, having great requirements, and, consequently, restricted conditions of existence. Here is another mode, enabling it to pass through trying circumstances without danger. When the organism grows old in a liquid, when it has exhausted the elements that can be assimilated of the latter, and has deposited therein its own products of elimination, which it does not only not require, but which it must avoid at any cost, there will be seen to form at one or several points of the filament (Fig. 2), or at one of the extremities of the short and isolated specimen (Fig. 10), a small mass more refractive and more brilliant than the remainder of the protoplasm, the outline of which, always ill defined and vague, becomes more and more black and thick. This is the *spore*, whose form and nature were for the first time described by M. Pasteur in 1869. When the spore is ripe, the filament disintegrates and gradually disappears. The functions of nutrition are then suspended: the respiration is so slow that it has been believed to have ceased. But there is no mistake about it, the spore is alive, more so even, in a sense, than the agile and active rod or germ which it has replaced, for it supports with impunity conditions of existence under which the adult animal would soon perish.

The question is so important that we must dwell on it. With this view, let us compare the effect produced on

microbes and their spores by the two dominating influences of the world of the infinitely small organisms, viz. the influence of oxygen and that of heat.

Air is a necessary element in the life of microscopic beings, at least of most of them. But, there must be nutritive matter present, the combustible must exist side by side with the agent of combustion. When a microbe becomes old in a medium which it has inhabited, and when the changes in its substance become less active, from one of the causes we have indicated, if oxygen continues to arrive, it is on the substance itself of the microbe that it acts. The slow but continuous respiration of the living organism gradually burns up its tissues by an action analogous to that of inanition. The microbe gets weak, its rejuvenescence becomes more and more laborious and difficult, and necessitates more and more restricted conditions of medium. With the microscope we can see its protoplasm, at first fluid, gelatinous and homogeneous, become granulated, and undergo a degeneration analogous to that observed in the dead or dying cells of the tissues of the higher animals. Death at last puts an end to this series of disintegrations. We shall soon see the connection between these phenomena and the decrease of virulence in cases where the microbe is pathogenic. For the present let us be satisfied with observing the hygienic function of air under the circumstances we have just examined.

But everything changes if the organisms submitted to its action have been able to terminate their protecting evolution as spores. The suspended nutrition, the hardly perceptible respiration, the force and the resistance are alike modified, and the balance can be maintained for a very long time. Of all microbes, the most sensitive to the action of air are those among which the spore form is unknown, the Micrococci. Next come Yeasts. But Bacilli offer an extraordinary resistance. Whereas a year's contact with air at its ordinary temperature is sufficient to kill the immense majority of Micrococci, I have found some kinds of Yeasts still living, at the end of

seven or eight years. As to the Bacilli, I only found a few dead after this interval, of the species that dread the contact of air during their normal life, and that we shall soon learn to know under the name of *anaerobiæ*. With regard to the others, nearly all those I examined were still alive, and indeed some did not seem to have suffered at all.

When preserved in closed receptacles, where the oxygen disappears gradually, the life of spores lasts still longer. I have found some alive, at the end of a quarter of a century, whose activity was not more impaired than if they had been a day old. There is nothing to lead one to suppose that they were in any way affected by this long torpor, and it would seem likely that, after another quarter of a century they would be found as they are now.

We see what prodigious vitality they have. Let us hasten to add that this mode of preservation, in a liquid from which air has been excluded, is rare in nature, where the spore is especially liable to be dried up or carried away by the wind. Now, under such conditions, I do not think that there would be a single spore alive in 20 years' time. I have experimented with wads of cotton of that age filled with millions of germs gathered from the air during 21 years, and all these germs proved to be sterile. But as a rule such a period is not necessary. All that is required is that the species should undergo a few days' or a few weeks' suffering or privation. Such is the use of the spore. Like the grain of plants, it represents the resistance of the individual specimen and the preservation of the species.

In relation to heat, we shall witness the relatively indestructible nature of the spore. Each microbe has a favourite temperature, in which it can reproduce more rapidly and more abundantly, and from which it does not like to move. Below this temperature, it will not flourish, suspends reproduction, ceases it altogether when zero is approached, but always seems ready to revive under the influence of warmth. Above this temperature it suffers also, but in another way. Not only does it fail to multiply, but it gets weak, its protoplasm alters, and becomes

granular, its rejuvenescence becomes more difficult and more slow. It appears to go through a series of degradations analogous to those it undergoes more slowly when in contact with air at a lower temperature. In fact, it would seem, from what occurs, that the only effect of heat is to heighten the influence of oxygen, and in the one case as in the other, death is the result.

This fatal temperature varies according to species. It averages from 50° to 60° C. for the micrococcus, 55° to 65° C. for yeasts, and 70° to 100° C. for bacilli. As a rule, to which there are but few exceptions, it may be laid down that all species of microbes, when adult and in course of reproduction, die at the temperature of boiling water.

But this is no longer the case with regard to spores. To kill them, they must be subjected for a few minutes to a temperature of 110°, 120° and even more. This accounts for the persistence of life in boiled liquids, and the difficulty of solving the question in our first lecture, as to whether boiled beer-wort would be altered or not.

Nothing could better illustrate the difference in the degree of resistance to heat between adult organisms and their spores than Prof. Tyndall's well-known experiment. An infusion of hay will not be sterilised by three hours of continuous ebullition, and becomes full of living organisms after two or three days' exposure to heat. But it may be rendered sterile by three minutes of ebullition, at the rate of a minute a day during three consecutive days. This is because the first day's boiling destroyed the adults. The spores resisted, but in the interval between the two ebullitions, especially if the liquid is kept in a room at about 30° C., they develop, become adult, and then succumb to the second boiling, or the third, should anything have happened to delay their development.

We have dwelt at some length on the difference in resistance to air and heat of the microbes and of their spores, because these facts have practical consequences in which hygiene is directly interested, and about which we must now say a few words.

The first relates to the dissemination of germs in the air. So minute organisms, forming still smaller spores, existing in innumerable quantities of the dead animal and vegetable matter with which the laws of nature fill land and water, must evidently spread in abundance through the air, and incessantly so. But there they meet with causes of destruction, which also work in a continuous manner. Desiccation, the action of oxygen, and, sometimes, of atmospheric ozone, are the principal of these. We may add the influence of that portion of solar heat which is arrested by the living corpuscles suspended in the air. Finally, we may mention, an element, the influence of which I have found to be sensible, without having yet been able to measure it, viz., solar light.

A few weeks, often a few days, thus suffice for the destruction of the microbes, and even of their spores. They do not all perish, and some, endued with greater powers of resistance, are seen to survive, and it can even be predicted at once that these resisting germs are also more numerous and more widespread. But, generally, and without taking into account this natural selection, the great majority of the organisms that are poured at a given moment into the air from a determined portion of the surface of the earth, disappear before getting very far away from their point of departure. A long journey, in the air, of the germs of an epidemic gathered from an infected locality, will, in the first place, mix them in an enormous volume, will scatter them, and moreover will weaken, and even kill them. Deadly when they start, they can, at the end of a few days, only produce *disease* in a modified form, or a local and unimportant disorder.

If, therefore, air *must* constantly contain living germs, it *must* contain a far greater number of dead ones, and ones that are incapable of reproduction. Experience entirely tallies with this conclusion. The innumerable particles of dust that are seen floating in a sunbeam penetrating into a darkened room, are, for the most part,

either mineral substances which have never had life, or organisms which have lost it.

This point settled, a remark occurs. The number of cells remaining alive will be the more restricted as the causes of production and dissemination are the less powerful around the point of observation. Indeed, it is only these that can vary much, through the presence or the absence of decomposable organic matter, the agitation or the calmness of the air, &c. The causes of destruction, as represented by the action of atmospheric oxygen, are always nearly the same. Hence, fewer germs, for instance, will be found in the air on hills than in plains, in a frozen desert than in fertile soil, away in the country than near dwellings, in a private house than in barracks or schools, in a cellar or cave where the ground is dry and the air calm, than in a damp, windy yard. All these facts, which are elementary now-a-days, had to be laboriously established in the first instance, and they are especially due to the experiments of M. Pasteur. All that has since been learnt on the subject, leads to the conclusion that air is relatively poor in living microbes.

In the case of solids and liquids, it is quite different. The upper strata of the soil are impregnated with decomposing organic matter, and are not only peopled, but saturated with spores whose functions have ended, of adult microbes, working and multiplying, of germs awaiting the conditions that will promote their development, and hampered or stifled by the superabundance of life around them. Microscopic generations have been succeeding one another for centuries past, and the process of destruction is slower than in the air, on account of the presence of alimentation, of the relative rareness of oxygen, of the persistent dampness of the under-soil, &c. The water from the heavens which falls after having, as it were, roughly washed the air, is impure when it reaches the surface of the earth, and is still more so when it leaves it. Whether it has only skimmed the surface, or has penetrated a little way, it will be found to be wonderfully full of life. Any

contact with our clothes, with our implements, with anything, will leave more or less adhering deposits of germs which will resist the action of light currents of air, which sometimes will not even be visible with the microscope, but which, if multiplied in a drop of organic liquid, will become visible to the eye. An easy calculation will illustrate the power of this means of dissemination. Paris is supplied with water from the valley of the Vanne, at a distance of 170 kilometres. It is the purest water that could be found, and, indeed, it is remarkably pure. This water is brought to Paris through a covered aqueduct, and at the time it flows into the city reservoirs, it contains at least 60,000 germs per cubic centimetre. We must not be surprised at these figures. It has been seen just now that the whole of these germs together do not weigh a tenth part of a thousandth of a milligramme.

On the other hand, I have found that, when a solid is washed without being wiped, the layer of water spread over its surface is about five ten-thousandths of a millimetre. With one cubic centimetre of water from the Vanne, it would therefore be possible to cover a surface of two square metres, and if 60,000 germs were distributed over this surface, this would give three per square centimetre. Now, I repeat, this is good, pure water, and is a hundred, a thousand times less impregnated than most of the water used for domestic purposes. It will therefore be understood what a source of infection may lie in the smallest solid body touched or washed by the water in ordinary use, or the smallest piece of linen or stuff it may have impregnated. Compared with germs of this origin, those brought by air are hardly worth mentioning. We may conclude that, in all cases of contagion, it is solids and liquids that we have to guard against. Direct contact with a patient, with anything he may have touched, with a cloth he may have used, with the finger or the instrument of the surgeon, is far more dangerous for his neighbours than breathing the air in which he has lived.

The proper ventilation of hospitals is the subject of much

attention, and very properly so, but sufficient care is not given to the far more active transmission of germs by means of solid or liquid bodies.

Where and how would it be possible to find, or obtain, such bodies deprived of the germs? To this question there are two answers, one of which has practical consequences, and the other a theoretic value which we shall determine later. Practically, pure water can be obtained by heating it for ten minutes at 125° C. in a Papin's apparatus, or a steam generator. Solids can be sterilised by dry heating at 150°, or, by heating in water, or steam, at a pressure of two atmospheres, when they cannot be brought into contact with flame, or be dry heated. All these are simple means. As to the question of economy, only compare it with the hundreds of human lives which such means will save.

Besides these artificially sterile liquids and solids, there are the natural sources. The earth is a powerful filter, it retains with such energy, through its capillary passages, the solid bodies which water carries with it, that, at the end of a certain transit in the depths of the earth, this water is entirely freed from the germs taken from the surface. The springs fed by such water are generally pure, especially in volcanic and primitive soils. In calcareous soils, where the water does not pass through imperceptible fissures, but through wide openings which it makes for itself, it may be different. The water from the Vanne is a case in point.

In the same way, compact masses of soil, such as are not touched by the plough, and are sufficiently deep to receive none but purified water; others again—and they are more numerous than is thought—whose impermeability is absolute, and where water has not penetrated since the geologic epoch: all these are as germless as the water proceeding from the depths.

The earth has sometimes been compared to a great living organism. This comparison may help us to picture to ourselves how the germs are distributed in the living being. On the surface, on the skin, in permanent contact with air and water, there will obviously be a great

many. There will be still more in the intestinal canal, which has so much organic matter passing through it. But blood, urine, and the really internal fluids of the economy, only communicate with the exterior through membranes, mucous or otherwise, which play the same purifying part as the deep strata of the soil. If these membranes are intact, if there is no wound, the urine, the blood, and the tissues should be germless.

This M. Pasteur has verified. It does not follow that such ought always to be the case with a man *in good health*. This impression has only a relative meaning. There are cases, as I will show, where apparently good health may be co-existent with the temporary presence in the blood of inoffensive germs, or of the germs of diseases of a mild form. But that is the exception, and the body of animals and of man is usually impervious to the germs of microscopic organisms. Such is the theoretic conclusion which I was speaking about just now, and which we shall have to utilise later.

LECTURE III.

THE GASEOUS FOOD OF FERMENTS.—"AIR LIFE," AND "AIRLESS LIFE," (*Aerobie et Anaerobie.*)

Summary—Yeast-life in the absence of air—Yeast is then a *ferment*, and decomposes sugar into alcohol and carbonic acid—Life in contact with air—It burns up sugar, and is very prolific, like the higher plants—The latter are also able to live without air, and are *ferments*—Relations between these two modes of existence—Sugar in fermentation a source of nutrition and heat to yeast—Theory of alcoholic fermentation.

THE restricted limits of this work do not admit of an examination of each of the various kinds of ferments, not even of those which are of the greatest industrial importance. But we shall endeavour to connect, with the best known facts of the best known of these ferments—viz. alcoholic ferment—some general notions, which, together, will make up a tolerably complete summary of all that we know concerning the world of these infinitely minute organisms. The question will be treated in a general form, in which details will not appear, but in which, I trust, the broad lines will be all the more apparent.

Starting from this point of view, the history of microbes can be reduced to an examination of their nutritive requirements, and of their means of satisfying them. It is there that the great difference between them and the higher animals is to be found. The latter are also formed of cells individually nearly as small as those of ferments; but these cells, which possess various properties, and are bound up in various tissues, are naturally subjected, through the medium of the blood, the nerves, and the muscles, to a series of profound and complex actions, on which physiology

will gradually throw light. The study of microbes is exempt from such complications. Here, the cells are free and independent; their principal, we might say, their only occupation is that of feeding; the latter only depends on questions of alimentary matter, of temperature, of moisture, which we can master. The problem is, therefore, relatively speaking, an easy one. Let us study it carefully. We shall be rewarded by the discovery that its solution, once found, can be applied in a general manner, and will supply a key to the understanding of the nutrition of the higher animals.

This nutrition necessitates the presence of a certain number of different elements, which may be divided into four principal groups. Every cell contains nitrogenous organic matter, non-nitrogenous matter, and a mineral matter. It must therefore have, in the way of nutrition, 1. nitrogenous; 2. carbo-hydrates; and 3. mineral matter. Every cell breathes. It must therefore have, 4. gaseous aliments. Let us begin with the latter. We shall see what a fertile subject of study they afford.

It may be thought, at first, that yeast does not breathe; in the sense that we usually attach to the word, that is to say, that it does not require oxygen. To produce a fresh fermentation, we have seen that the brewer takes the seed from a former fermentation, where the liquid is saturated with carbonic acid, and does not contain air. Once it is in the wort, the yeast almost immediately produces carbonic acid, and is in an atmosphere where there is no oxygen. This has been taking place for centuries, and the yeast we use at present seems to descend from that which the brewers used in Egypt 6000 years ago, by a series of generations and a process which must have taken place in the absence of oxygen apparently.

But we must not form hasty conclusions. In the first place we must remark that the liquid in which the brewer places the seed is not deprived of air. On the contrary, some of these time-honoured customs, such, for instance, as spreading out the wort, in a sweetened state, for cooling,

have the result, perhaps intentional, of aerating the liquid. Another practice, customary in certain breweries, seems to have been specially designed to promote the aeration of the yeast also. Before pouring the yeast-seed into the wort, some brewers are in the habit of passing it from one receptacle to another, taking care to pour it from as great a height as possible, which has the effect of transforming it into a frothy mass, saturated with air. Thus, the yeast comes, aerated, into an aerated liquid. During one period of its existence, at all events, it is in contact with oxygen. But is this gas essential, or is the process of aeration merely an incident, which yeast can, and perhaps ought, to dispense with? That is what we do not yet know.

To ascertain this, let us prepare some sweet wort, whence the air has been removed by the process of boiling and cooling in carbonic acid. In order to produce fermentation, let us add, taking the necessary precautions to prevent air coming in during the operation, some yeast gathered from a good fermentation, and proceeding therefore from a liquid totally free from oxygen. We shall observe two things—

In the first place, the fermentation is accomplished thoroughly, and in the conditions indicated in Lecture I., *i.e.* 100 grammes of sugar give nearly one gramme of yeast, and the rest splits up into alcohol and carbonic acid, with concomitant formation of the various products, succinic acid, glycerine, and fatty acids, which we have enumerated.

In the second place, the fermentation takes a long time to begin, and always proceeds with extreme slowness. This slowness is dangerous to the brewer. Instead of the yeast sowed, there might be developed in the wort, the germs which are invariably to be found in water, or on the sides of the vats or receptacles in the brewery, and those which always exist, more or less, in the yeasts used in trade. All these germs are better adapted, than is yeast, to exist without air. Their development, in however slight a degree, in the wort or beer, affects the flavour of the produce. The brewer has every interest in preventing such intervention. Perhaps this is why he exposes his vats and his yeast to

the air. Anyhow, we see that although yeast may flourish out of contact with air, it does not like it. It can put up with it, but it is not what it would prefer.

Now let us deal with the other side of our argument, and our experiment. Let us endeavour to secure the presence of oxygen during the whole period of the contact of the yeast and the sugar. This is not easy. We must give up the idea of a flask, or even of a cylindrical vessel, to contain the wort, because carbonic acid expels air from the interior and the surface of the liquid, and, on account of its great density, covers it with a gaseous stratum, through which the oxygen cannot pass. In order to avoid too great a disengagement of gas we shall even abstain from using deep vessels; but we can operate in shallow basins containing a very thin layer of wort. Now let us put in a little yeast. The contrast with the first experiment will be complete.

The yeast will, under such circumstances, begin to bud and to multiply actively. Such were the conditions of M. Pasteur's experiment, as mentioned in Lecture II., when, in two hours, two globules of yeast increased to eight. Here, the reproduction is easy and abundant, and whereas, just now, only one gramme of yeast was formed at the expense of 100 grammes of sugar, the result is now 25. The manufacturer of yeast has every reason to be satisfied, and, indeed, these are the conditions of perfect aeration which he aims at in his calling, and which he does not always sufficiently attain. But the brewer, the manufacturer of alcohol, for whom yeast is only a secondary consideration, has not the same reasons for satisfaction. Let us see why.

In the first place, these 25 grammes of yeast have, in the forming of their tissues, neutralized a certain quantity of sugar,—it is impossible to say exactly how much, but no doubt very nearly the weight of yeast formed. The materials of this yeast proceed, as we know, almost exclusively from the sugar. Now, the volume of the materials in a building is always very nearly the same as that of the rough stone

employed in its construction. On the one hand must be deducted the waste, on the other must be added the mortar, the ironwork and cement, which are necessary to give cohesion to the whole structure. This makes a sort of balance between the two. Thus we have 25 grammes of sugar which have taken the form of 25 grammes of yeast. This constitutes a first loss to the brewer, whose principal object is to make alcohol with his sugar.

But will the remaining 75 grammes of sugar have supplied any alcohol? According to the usual mode of fermentation, they ought to have yielded half their weight of it. Now, we can only find traces of it. The liquid in which the yeast has thus lived, exposed to air, is not beer. It is a flat, tasteless liquor, where there is, so to speak, no alcohol, but whence the sugar has disappeared not the less. What can have become of it?

It is not difficult to see that it has been completely burnt up by the oxygen, whose permanent contact with the liquid we have assured. Thanks to this oxygen and to the yeast, the sugar has been nearly all transformed into water and carbonic acid. The portion that has been changed into alcohol is so insignificant, that it does not deserve notice; so that we now find ourselves in presence of a phenomenon in which yeast and sugar take part, in which the yeast multiplies and the sugar disappears, and in which there remains nothing of the essential character of alcoholic fermentation. It is the exact opposite of our first experiment.

In trade we may at once observe that the brewer keeps equally aloof from these two extremes, or rather, he undergoes them both in succession. Aerated yeast, placed in an aerated liquid, lives after the fashion shown in our second experiment, *i.e.* it multiplies, and consumes sugar and oxygen, without producing much alcohol. But this first period does not last long. The oxygen which is there at first, is partly consumed, and partly expelled, by the disengagement of carbonic acid, so that at the end of a few hours, if the temperature is favourable, the existence without air

begins. It is during this life that the greater part, nearly the whole, of the sugar disappears. The whole of this complex phenomenon, while comprising both modes of life of the yeast, with air, and without, belongs almost entirely to the second one, and is in our eyes the type of what is called alcoholic fermentation.

But, although, in practice, we see very well how life with air is connected with life without air, it seems at first to be impossible to discover, theoretically, a connecting link between these two modes of existence.

In the one case, we see yeast, taking oxygen from the air, sugar from the ambient medium, and actively producing new cells. There is nothing, then, to distinguish it from a beetroot, producing its leaves and organs of fructification by means of the sugar accumulated in its roots during its life beneath ground. The only difference is that the beetroot makes this sugar for itself—and finds it in its cells—whereas the yeast must get it from outside.

But this sugar, coming from without, made, perhaps from beetroot, must penetrate, by endosmose into the yeast-cells, in order to be utilized. In the latter, therefore, as in those of the beetroot, the consumption is *internal*. The resemblance does not end here. We shall soon see that the machinery of alimentation by means of this sugar is the same in both cases. We have just seen that, in one of the two cases, we arrive at the formation of new cells, that, in both cases, while a somewhat considerable part of the sugar,—a quarter in the case of the yeast—assumes the form of living vegetable matter, and rises in the organic scale, another part, a still larger one, descends and becomes water and carbonic acid. It is so throughout the world of living organisms. Nowhere are new cells ever produced without an absorption of oxygen, and the concomitant destruction of a certain amount of alimentary matter. In its mode of existence in contact with air, in what we shall call its *air-life* (*aerobie*), yeast therefore resembles all other plants.

In life without air (*anaerobie*), all seems different. There is no longer any oxygen present in a gaseous state, and it

is evident that the yeast has greater difficulty in living. Some is still formed, for life and reproduction are as it were synonymous, but we have only one gramme, instead of twenty-five, for 100 grammes of sugar. On the other hand, whereas the 75 grammes of sugar, which disappeared in air-life, became water and carbonic acid, the 99 grammes of sugar which do not appear as yeast, in life without air have undergone a real alcoholic fermentation.

We saw just now that yeast in its air-life resembled other plants. Let us see now whether other plants do not resemble yeast when grown in the absence of air. If a beetroot be put in carbonic acid, it will produce alcohol. Let us also treat in the same way, cherries, plums, apples, any sweet fruit, or sacchariferous plants, whole. The sugar they contain will still partly turn into alcohol and carbonic acid, under these new conditions of life. The only difference between them and yeast is that they are much less able to exist in the absence of air, that they do not carry fermentation so far, that they stop or die, before having transformed all their sugar. But these are merely differences in degree. The main point is to have seen that the correlation between alcoholic fermentation and the exclusion of air is common to a long series of living organisms. Yeast is one of the terms of this series, but not the last, for we have seen that, after all, it requires a little air, and we shall find microbes to whom air is not only useless, but injurious.

However, to generalise the phenomena presented by yeast is not to explain them. How are we to understand two such different modes of existence? How can we understand the possibility of yeast passing from one mode of life to the other, without any apparent effort? For in a fermentation, produced in the usual way, and where air-life gradually becomes airless life, nothing in the shape or appearance of the globules suggests the change. The form is the same, so are obviously the requirements. The requirements of a living cell are the most fundamental of its specific characteristics. Fortunately, if they are invariable, the means of satisfying them are not so.

Let us take a step in this direction. In air-life (*aerobie*), yeast obviously requires air. It consumes oxygen (in a *free state*). Does it also require oxygen in its airless life (*anaerobie*)? Undoubtedly so. But where is it to be got? There is none in a *free* state. It must therefore be obtained from some organic substance containing oxygen, and as there is no other except sugar that can supply the necessary quantity, it is sugar that will be called upon for the contribution. The connection between the two notions of fermentation and airless life had already been proved by experiment, against which nothing can prevail. It has now been established by an argument, which may be a subject for discussion, but the value of which it would be impossible to ignore. Yeast is a living organism requiring oxygen, which it can obtain from sugar when it cannot be got elsewhere, and then turning it (the sugar) into alcohol and carbonic acid. For this, when free from air, it decomposes 99 per. cent. of the sugar, taking the remaining 1 per cent. to build up its own substance. In contact with air, 25 per cent. of the sugar becomes yeast, at the expense of the remaining 75 per cent., which are burnt. There is, therefore, a connecting link between the two yeast-lives; viz., the necessity of oxygen.

Between the sources whence it is derived there must therefore exist some system of compensation—the mechanism of which we have not yet quite grasped. Let us try and do so a little better. It is a delicate subject, and we may think it difficult and laborious of access. But in science as in war, difficulties are nothing, so long as one progresses. Now, the step forward we are about to take is absolutely decisive. We have just discovered that there is a certain compensating arrangement between two phenomena apparently so different as combustion of sugar and alcoholic fermentation. Let us try and find out where this compensation appears. We shall see that it is in the production of heat.

The growth and formation of any cell necessitates a certain expenditure of force, represented by the consump-

tion of a certain quantity of food or nourishment. A seed sprouting in darkness consumes and burns a part of its substance in order to raise another part to a higher level of organisation. It thus produces heat, of which part becomes ascertainable by the thermometer, as, for instance, during the malting of barley, and part is neutralised, or expended, in the tissues of the young plant. Yeast does not act otherwise. Alcoholic fermentation of sugar produces heat, part of which raises the temperature of the mass, and part is used in constructing new cells. This is the case, also — appearances notwithstanding — with the whole plant, furnished with all its organs, and with its *green matter*. There is this additional circumstance, that the latter has now to prepare the nourishment, which the gemmule found ready made in the seed, and which the yeast found prepared in the wort. But when this nourishment has been prepared, and even stored in the higher plant, it is steadily consumed as new tissues are formed. In short, nowhere, in the world of living organisms, is a single cell formed without an expenditure of alimentation, or of force. This might be termed the cost of construction.

This is not all. The cell, once supplied, is intended to live, that is to say, to resist the causes of destruction, to become the centre of a ceaseless renovation, in fact to perform a continuous work. Hence the necessity of a fresh expenditure, proportional to the extent, and the intensity of life. We may call this the cost of maintenance. Of course, it is understood that the distinction which we have drawn between the cost of construction and the cost of maintenance, does not exist in nature. Maintenance co-exists with construction, and reconstruction occurs pending, and for the purpose of, maintenance. We can only observe the combination of those two phenomena. But the human mind has a great defect: it can only arrive at synthesis by analysis. It is in deference to this tendency that we make the distinction mentioned, the necessity of which cannot, indeed, be denied. To use a crude simile, the cost of construction represents the expense of starting

a house, the cost of maintenance, the daily expenditure for keeping it up.

What is required to provide for this double expenditure? A form of nourishment which shall supply heat and strength. In the case of air-life, this source of energy is not difficult to find; it is the result of the action taking place between the sugar consumed and the atmospheric oxygen. The 25 grammes of yeast which can then be obtained, in 2 or 3 days, with 100 grammes of sugar, find their cost of construction in the heat developed by the complete combustion of the remaining 75 grammes.

In life without air less yeast is produced, at the expense of 100 grammes of sugar, viz. one gramme instead of 25. The cost of construction is therefore less, but the phenomenon is slow of accomplishment, and the cost of maintenance, which was insignificant latterly, as compared with the cost of construction, now becomes important. Anyhow, there is expenditure. There must therefore be a source of heat somewhere. Now, there is no other phenomenon capable of supplying it except the decomposition of sugar into alcohol and carbonic acid.

This decomposition must, therefore, be a source of heat. In more general terms, a substance capable of fermentation must disengage heat in fermenting when deprived of air. This is a first and important consequence which we shall soon have to utilize. Here is another. These fermentations can never be very powerful sources of heat. For instance, it is true that sugar yields the same carbonic acid as in complete combustion, but in lesser quantity; a third of its carbon assumes that form instead of the whole, a first cause of inferiority. Moreover, the fermentation leaves a residue of alcohol, a substance which is still combustible, and still contains, in an available condition, part of the heat of combustion of the sugar. To sum up, it may be estimated that 100 grammes of sugar when they turn into alcohol and carbonic acid, give out 10 times less heat than when undergoing combustion in contact with air. Hence, to obtain the same amount of heat, the yeast must destroy

10 times more sugar when making it ferment in the absence of air than it destroys in its air-life, to attain the same end. To put it in more general terms, a fermentable substance is decomposed by its ferment into products, the quantities of which are in inverse ratio to the amount of heat resulting from the mode of decomposition, *i. e.* the less the heat, the greater the product. And here we have the secret of the disproportion between the quantity of active ferment and the quantity of fermentable matter destroyed, a disproportion which we included in our definition of the word *ferment*, without quite understanding its construction, but which is clear to us now. To make use of another common-place comparison, there is, between "airless life" ferments (*anaerobies*) and "air-life" ferments (*aerobies*), the same difference as between two exactly similar steam-engines, one of which makes good use, and the other bad use, of its fuel. The latter will consume twenty or thirty times more than the other, for the same work.

To conclude, fermentation has, I hope, ceased to be for us an isolated and mysterious act, incapable of explanation. It is the consequence of the nutrition and of the existence of the cells under special conditions, which differ in most cases from those of their ordinary life, and to which yeast appears to easily adapt itself during the course of its career as a ferment. But, as we have seen, yeast by its life in contact with air, approaches ordinary plants; we have also seen that plants, by living in carbonic acid, possess the properties of yeast. Thus, a continuous chain connects all these cells so dissimilar in appearance. They only differ inasmuch as they present, in different degrees, the two fundamental aspects of life with air, and life without air (*ærobie et anærobie*).

LECTURE IV.

MINERAL FOOD OF MICROBES.

Summary—Conditions of solution of the problem—Cultivation of "aspergillus niger" in a mineral medium—Scale of utility of the different components of this medium—Functions of zinc and iron—Agricultural results—Chemical manures.

THE infinite exiguity of the organisms we are studying, the extreme simplicity of their forms and their organisation, the ease with which they develope in organic liquids, the multitudes that a single drop of infusion will suffice to nourish, all that we hitherto know about them, might lead to the belief that their alimentary requirements are not very restricted. It is quite the reverse; for weighty reasons, which will appear in our last lecture, microbes are as fastidious as the highest in the scale of living organisms. We shall find that most of them will seek for food containing carbohydrates, and be very particular in the selection of their nitrogenous aliments. We shall see that, in the way of mineral nutrition, they will require mixtures both of a complex and special nature.

This question of mineral alimentation, in appearence so futile and so thankless that it has hardly been dealt with in regard to the higher plants, will, as regards microbes, lead to unforeseen facts, to considerations well worthy of study, and to conclusions which may be said to come within the scope of agriculture. For this, we must proceed as follows. In the experiment on yeast, described in our first Lecture, M. Pasteur showed us microscopic organisms, living and developing in artificial media, into which, apart from the fermentable matter, there only entered pure mineral salts, of known composition. Let us see which of these salts the

plant requires, and which of them are useless or injurious to it.

The presence of the former is evidenced by an increase in the weight of the plant, of the others, by the stationary character or decrease of the produce. Thus, with patience we can form a *typical medium*, which will give the maximum production. Then, if in this medium we suppress or withdraw, one by one, the various elements we have introduced, we shall be able to estimate, by the reduction in the produce, the raising influence of the elements thus suppressed, and to get at what M. Boussingault has wittily called the "opinion of the plant" on the subject.

If this problem is easy to set, it is not easy to solve. The first thing is to construct completely the most favourable medium for the life of a microscopic species. This means that, to solve the problem, we must suppose it solved. That result can only be attained by a series of methodical researches and of continuous labours, and by slowly building up the edifice step by step. It will not do to depend on chance, nor to neglect, in these attempts, a single one of the elements of chemistry. The number of combinations that may result by mixing these elements in every way, is infinite, and theoretically, there is only one of these combinations that is good, or rather, that is better than the others.

Moreover, once this artificial medium is created, it must yield a produce that shall be nearly constant or uniform, and as large as possible; uniform, in order that the decrease of produce resulting from the suppression of an element may be reliably put down to the account of this suppression; and as large as possible, in order to leave a margin for anticipated decrease of production, and so that the scale of relative utility which we wish to make out for the various elements, should be sufficiently large for them not to be mixed with each other.

Indeed, the problem has only been completely solved in the case of one vegetable species, and that is thanks to an admirable work by M. Raulin, which is not sufficiently

known. This species is of the "air-life" order (*aerobie*), *i.e.* it lives in contact with air. This, as we saw in our last lecture, is necessary to ensure its plentiful multiplication in a limited time, and in order that the production should be considerable. The species in question belongs to the group of the "mucediniæ;" we have not mentioned these yet, but the time has now come to describe their principal characteristics.

To this family of "*mucediniæ*" belong *Aspergillus niger*, *Penicillium glaucum*, *Mucor racemosus*, *M. caninus*, *M. mucedo*, etc., their common name would be moulds or mildews.

All these mucediniæ, of which the best known type is the common mildew, are composed of a radicular system, called *mycelium*, existing in the depths of the nutritive medium, and of organs of fructification, formed generally of a "colonnette" rising in the air, and bearing the fruit or spores. The mycelia of the various species are filaments, more or less branching, more or less wide, more or less partitioned, but, after all, very like each other; and it would be as puzzling to classify mildews as it was to classify microbes, were it not for the invaluable characteristics presented by the form and appearance of the organs of fructification. Figure 5 represents two of the most common species, in their general bearing (*a*), and in their mode of sporulation (*b*). Of these *penicillium glaucum* is that blue mildew, which is met with everywhere, in mouldy bread, on jam, on soft cheese. The sporiferous tubes are branched, separating at their extremity (*b c d*), into delicate "colonnettes" laden with waving rows of spores. From these spores (*f*), when placed in a nutritive medium, proceeds a plant identical with that whence they proceed. In the other species, which M. Raulin has studied, and which he calls *aspergillus niger*, the sporiferous tube is straight, not branching, and bulges at the end into a round capitulum on which grow bunches of spherical and slightly bristling spores (*c*). These spores, when sowed under favourable circumstances, soon become

as shown in (*d*), branching mycelium tubes, whose tangled

Fig. 5.

mass forms a white and thick layer. Then appear the

sporiferous filaments, whose black capitula make the mass look like thick velvet.

This aspergillus grows very easily on bread wetted with vinegar, on slices of lemon, or lemon juice, and generally on acid fruits or liquids; and one would be inclined to think that nothing could suit it better than these complex mediums. But M. Raulin has proved the contrary. The purely mineral medium which, after protracted and minutious researches, he has succeeded in preparing for his aspergillus, yields, in a shorter space of time, a living plant superior in weight to that supplied by any other organic medium. The first condition we mentioned just now is therefore fulfilled. So is the other. With the, apparently, most favourable natural media, the produce of the aspergillus is exposed to a multitude of accidents, and apparent whims of nature. In the artificial and mineral medium it remains uniform, to within about one twentieth of its value. Whereas, in nature, various kinds of parasites hamper and stifle it, here it chokes all cryptogamic vegetation, and covers the liquid, which M. Raulin has found for it, with a thick, homogenous stratum, of the most vigorous aspect.

Let us dwell a moment on this fact, and let us give it a wider range. We see that it is nothing but the struggle for existence between the organisms of creation. They all have their enemies or their parasites; they must destroy them, or be destroyed by them, and there are plenty of so-called natural laws to explain how they solve this dilemma in the most favourable sense. With regard to our aspergillus, the solution is simple; we know what are the conditions of the struggle in its case. They belong to chemistry, and not to physiology, where they are usually sought and found. It may be said that the aspergillus overcomes its enemies because it is stronger than they are; but then it is stronger simply because it finds in its nutritious medium all the elements which it requires. If one of these elements were to fail, it would still live, but with difficulty, and its power of resistance would diminish. If several were to fail, then it would dwindle, fade, and make way for a neigh-

bouring species, of a less exacting nature, or having other requirements, more easily fulfilled in a medium which has become a poor one for the aspergillus, but a rich one perhaps for the other species.

Such are the conclusions to be drawn from the general and preliminary observation just made. But if we now go into details, if we investigate the nature and weight of the sources of alimentation, whose presence or absence are indicated by such remarkable effects, we shall discover facts which are still more curious. To begin with, here is the composition of the nutritive medium of aspergillus, usually known as "Raulin's liquid."

	grammes.
Water	1500
Sugar candy	70
Tartaric acid	4
Nitrate of ammonia	4
Phosphate of ammonia	0·6
Carbonate of potassium	0·6
Carbonate of magnesia	0·4
Sulphate of ammonia	0·25
Sulphate of zinc	0·07
Sulphate of iron	0·07
Silicate of potassium	0·07

If we count the various elements of this liquid, and add the oxygen of air, which the plant consumes in great quantities, it will be seen that no less than twelve chemical substances are required for its full development. It requires, moreover, a temperature of nearly 35°, and moist air, suitably renewed, and it grows better on a liquid of slight depth. It is grown in shallow porcelain basins, which are left uncovered, and in which the liquid is from two to three centimetres deep. If, under such circumstances, the vegetable spores are sowed on the surface of the liquid, the latter will, at the end of twenty-four hours, be covered with a whitish and continuous membrane. This is the mycelium of the plant. Fructification begins the next day, and at the end of three days, the cycle of vegetation is complete. The plant is then removed, fresh

spores are sowed on the surface of the liquid that remains and, three days after, a fresh crop is gathered.

The two crops, together, represent twenty-five grammes of plant, weighed in a dry state, and the nutritive liquid is then completely exhausted.

Having got so far, let us deal with the question we began with; let us find out, for instance, the relative importance of potassium in the nutritive liquid; and with this object, let the plant be grown in two similar basins, one containing a complete preparation of the Raulin liquid, and the other the same liquid without the potassium. In the first case, the result will be, as usual, within a gramme, 25 grammes weight of plant. In the other case, there will only be *one* gramme. The crop has therefore fallen to $\frac{1}{25}$ of what it was. It will fall to $\frac{1}{200}$ if phosphoric acid, and to $\frac{1}{150}$ if ammonia be withdrawn. There is nothing to wonder at in this, except perhaps the smallness of the amounts. It has long been known that phosphoric acid, and ammoniacal salts, are excellent manures. But here is a curious fact. The withdrawal of the zinc would reduce the crop to $\frac{1}{10}$ of what it was in the complete liquid; in other words, would bring it down from 25 grammes to 2·5 grammes. Would it have been thought possible that zinc was a physiological element of such importance? And the quantity of sulphate of zinc employed is only 7 centigrammes, containing only about 32 milligrammes of zinc. The action of such a minute quantity of metal represents an increase in value of 22·5. in the crop, that it is to say it will give a weight of plant equal' to 700 times its own weight. Is not this a singular fact? Does it not seem still more so, when one reflects that this plant, so sensitive to the action of zinc, has to gather it from a liquid in which it is diluted in the homœopathic dose of $\frac{1}{50000}$! On what infinitesimal proportions of a useful element may depend the health of a living being, the prosperity of a cultivation!

Moreover, if we reflect that in a liquid containing only $\frac{1}{50000}$ of zinc, one or two generations of aspergillus might

by completely absorbing the metal, weaken or frustrate the existence of a new generation; that in such a liquid, a fresh process of sowing—I was going to say of inoculation—would be destined to fail, how is it possible not to reflect at the same time on the mysterious nature of virulent diseases, such as small-pox, scarlatina, typhoid fever, which never appear twice in the same person? There is, it is true, nothing to show positively that this non-recurrence, in the case of vaccinal virus, works in the same way as in the case of the seed of aspergillus; but how can it be denied that the two effects are comparable?

We have just seen how sensitive aspergillus is to the action of the elements which it requires; we shall now see that it is still more sensitive to those which are repugnant to it. If $\frac{1}{1600000}$ (*one sixteen hundred-thousandth*) of nitrate of silver be added to the nutritive liquid, the vegetation stops abruptly. It cannot even commence in a silver vase, although it is almost impossible, chemically, to show that any portion of the matter of which the vessel is made, dissolves in the liquid. But the plant, exceeding in sensitiveness that of the reagents, which are themselves so sensitive, of salts of silver, indicates, by its death, the presence of the poisonous body. It is affected in the same way by $\frac{1}{500000}$ of corrosive sublimate, by $\frac{1}{8000}$ of bichloride of platinum, by $\frac{1}{240}$ of sulphate of copper. A little reflection will give interest to these figures. Suppose the aspergillus were a parasite of the human organism, capable of living and thriving in and taking complete possession of it, as is the case, for instance, with the septic vibrio (figure 10), it would only require 60 milligrammes of nitrate of silver to remove it from the body of a man weighing 60 kilogrammes. A parasite, only developing itself in the blood, like the bacterium of carbuncle, and as sensitive as the aspergillus to the action of nitrate of silver, would not require more than five milligrammes of its poison.

There is another and final experimental fact to be noticed. As the plant does not contain any green matter,

it may be surprising to see that iron is one of its nutritive elements. Indeed the withdrawal of that metal produces results similar in importance to those produced by the suppression of zinc. The addition of one gramme of iron to the nutritive medium will increase the crop by 800 grammes. Notwithstanding this resemblance, the functions of zinc and of iron are quite different. Zinc enters the plant as a constituent of its tissues. The only use of iron appears to be to destroy or suppress, pending production, a poison which the plant secretes, and which, were it to accumulate, would end by killing the plant. It is one of those secretions which are common to all living organisms, and which they should get rid of at any cost. This is the service iron renders to the aspergillus. Zinc is a physiological aliment: iron is a physiological antidote.

We may observe incidentally that these facts may possibly lead to an explanation of the properties of vaccine, and the non-recurrence of virulent diseases, an explanation which differs from that we were aiming at just now. A first development of microbes, in a certain medium, may produce, either the elimination of a useful element, as in the case of zinc, or the introduction of an injurious element, when the utility of iron is illustrated. The amount of active matter may be infinitely small in both cases, and yet be sufficient to impede or frustrate a new generation of the same microbes.

The time has not come to choose between these two hypotheses. We must limit ourselves to calling attention to them.

We have seen what curious facts, what original and fruitful views, have been supplied to us by the study of the mineral alimentation of the aspergillus. We may assert that the other microbes are not less fastidious. Like the higher organisms, they all have their own particular and complex existence, their special requirements —substances they like and others they avoid. Yeasts like lime, which the aspergillus does not require: others want manganese. The "*penicillium glaucum*," so similar

to the aspergillus, grows well in Raulin's liquid, but it grows still better with the addition of a little gypsum. Not having the same friends, these organisms—which are so different—have not the same enemies either. Some will live in solutions of nitrate of silver, of bichloride of mercury, the mere trace of which salts would be deadly to the aspergillus. And this is fortunate, for, with the resemblances which we have indicated, and which we shall have occasion to indicate again, between the cells of these microbes and those of the human body, it might have been feared that what was food and poison to the former, might also be food and poison to the others. But it is not so. One kind of alimentation will promote the growth of the normal cells, and consequently health; another the growth of parasites, either virus or others, and consequently disease. In the same way, one form of medical treatment will destroy the disease and another the patient. The point is to know how to choose. Hitherto this has been done by empiricism; now the era of the experimental method seems to have dawned.

The facts we have been dealing with have another curious feature which we must notice before concluding. Examined by itself an aspergillus is a tiny plant. It is a thousand times less heavy than the smallest blade of grass; but thousands of blades of grass will make hay, and millions of aspergillus will yield a crop. A contemptible one, you will say. By no means; on the contrary. Twenty-five grammes of dry plant, obtained in *six* days in the porcelain basins we have used, represent a crop of 550 kilogrammes per hectare, in a dry state, or 3500 kilogrammes in a damp state. This is a yield which almost equals the fifth of that of a good natural pasture, and, I repeat, it was obtained in six days. Our microscopic form of cultivation has therefore no need to be jealous, in the matter of weight, of the higher branches of agriculture. It is the latter, rather, that ought to try and come up to the level of their neighbour, and borrow its secret.

Now, what have we learnt? We have learnt that a plant, when supplied with all its necessary aliments, will grow rapidly, is never subject to parasites, or diseases, and will yield a crop that will be uniform in quantity and quality. If one of the constituents of its food be withdrawn, the plant suffers, and this suffering is shown by an enormous decrease in weight, disproportionate to the amount of the aliment withdrawn. If zinc were only discovered yesterday, its employment in the growth of aspergillus would instantly increase tenfold the weight of the finest crops obtained.

We see what a scope is opened for the cultivation of the higher plants. How unlikely it is that if the requirements of a microscopic organism are so complicated, those of the higher organisms should be as simple as people sometimes profess them to be. When good farming is considered to depend on simply supplying the soil with phosphorus, potassium, magnesia, and nitrogenous matters, is it not evident that we trust to the soil to furnish the other useful elements, without knowing what they are? If the soil can do what it is asked to do, well and good; the artificial manure will give satisfactory results. But if the soil is unable, or at a given time is no longer able to do so, and if the missing element is of the same nature as zinc in the case of aspergillus, the crop will decrease without any apparent reason. To meet this, the dose of potassium or nitrogenous manure is increased at haphazard; but this may lead one beyond all bounds. There is something wanting in the soil, which manuring will not bring.

The reason of this failure is that the problem of mineral alimentation is not yet solved in the case of plants (the higher plants), whereas it is for the aspergillus. A day will come when cumbersome and costly manures will be given up, when the husbandman will have ready stored and labelled in his barn, the quantity of manure to be spread over a given portion of his various descriptions of soil in order to obtain such and such a crop. Agricultural experience has shown that this day has not yet arrived, but the experience of the aspergillus has shown that it

may come; and however remarkable may be what has been done in England and elsewhere in the matter of chemical manures, M. Raulin's labours may be said to exceed it in importance, because he has been the first to show that it was possible to obtain in a purely mineral medium, a more plentiful and a more thriving crop than in the most suitable organic medium. From whatever point of view they may be looked at, it will be seen how fruitful these labours are in information, and how thoroughly they deserve the place we have assigned to them.

LECTURE V.

THE HYDROCARBONOUS FOOD OF MICROBES.

Summary—Analogy between Fermentation and the decomposition of explosive substances—Gradual destruction of bodies in Fermentation—Air-life and airless life (*Aerobies et Anaerobies*)—Sugar as an example—Alcoholic and acetic fermentations—Lactic and butyric fermentations—Diseases of wine and beer.

WE have seen that beer-yeast is a ferment of sugar, but it is not the only one. There is another which we shall learn to know by the name of *lactic ferment;* there are others which are less known, and which we shall not even name; and certainly there are many that are not known at all, and that remain to be discovered. Nor is this multiplicity of ferments peculiar to sugar. All complex organic substances may, similarly, serve to support, either together or successively, various microbes, each of which will exert a special action. There is, therefore, a vast number of fermentations of different kinds; and were we to attempt to specially examine, even briefly, the best known or the most important of them, this alone would carry us too far. I prefer to extract the general characteristics from this mass of facts, and substitute substance for detail; and, for this, I do not think I could do better than to examine them from the point of view of their relations to the nutrition of microbes.

Remember what we learnt, in the last lecture but one, respecting fermentable matter. It was shown that its destruction by a ferment must necessarily produce a disengagement of heat, part of which the ferment uses as a source of strength; the other part heating more or less the mass in fermentation, and finally disappearing in the air.

When gunpowder, or nitro-glycerine, is exploded, their chemical molecules, amid a considerable emission of heat and light, undergo a fresh series of groupings, part assuming the shape of an inert residuum, whilst the remainder, the gases, escape with violence. Putting aside the question of power, the same thing occurs with a piece of sugar in a state of alcoholic fermentation. Here, also, there is a decomposition of a complex substance, and a concomitant production of heat, which every brewer endeavours to moderate. Here likewise, this decomposition results in a residuum, alcohol, and a gas capable of overcoming all obstacles. A cork, flying out of the neck of a bottle of champagne, and a ball fired from a gun, are set in motion by the same force; and the resemblance goes further still. It only requires the smallest spark to fire the largest piece of ordnance, and it only requires a globule of yeast to put large quantities of sugar into fermentation. In both cases, when once the decomposition begins, it continues, through the very heat it develops.

Instead of sugar and yeast, we might have taken another substance and another ferment. To generalize, if any organic body be composed of a grouping of molecules sufficiently complex to cause, by their separation into two or more fresh groupings, an emission of heat sufficient to sustain a ferment, such a body shall be fermentable by this ferment.

This definition considerably extends the scope of cells as ferments, and we have seen that this induction has been confirmed by facts. But on the other hand, it restricts the field of fermentable substances, by showing that the latter can only be considered as such so long as they can produce heat in their decomposition.

This point settled, we can proceed. The sugar, when it disappears as such, leaves alcohol in the liquid. Why does it leave alcohol, and, to speak generally, what does this non-fermentable residuum left by all ferments, correspond to? The residuum left by powder fouls the gun, and can no longer burn, because it no longer contains any internal heat.

In the same way, the alcohol-residuum is left by yeast because it (the residuum) no longer contains any heat that can be used by the ferment. The physiological conditions of the living organism, as well as the natural forces set in action by the explosion of powder, extract from the substance which is in course of decomposition all the heat available under the conditions in which the phenomenon takes place, and, in either case, there only remains untouched that from which there is nothing more to get. Hence a certain number of consequences.

In the first place, the same substance, especially if it is of a very complex nature, will, in decomposition, be able to produce a certain number of different divisions or groups, that is to say it will undergo a certain number of different fermentations. Those of the ferments which require the most heat will carry the work of destruction further, and will leave simpler residuums. The others will leave the dismemberment or decomposition in a less advanced stage, and residuums of greater complexity.

The last mentioned residuums, which are unimpressionable as regards the species that produced them, may be fermentable by some other, of more restricted requirements. They may, therefore, be simplified by these two successive fermentations.

The structural connection between all the residual clusters or groupings thus formed, and the original body will, of course, only be of a somewhat distant nature. When a building falls to pieces, it may do so in a variety of ways, and the portions left standing convey but a vague idea of the original structure, and its arrangement. So it is with chemical compounds. Sugar can supply ordinary alcohol, propylic and butyric alcohols, acetic, propionic, butyric, lactic, and oxalic acids, and mannite, all being bodies which, as regards their constitution, have no relation either to each other or to sugar.

These residuums will be found to be the same in the destruction by fermentation, of a large number of various compounds; and their composition being simpler than the

bodies whence they proceed, they must, therefore, be less numerous. We have just enumerated the most familiar of the products of the fermentation of sugar. The same will be found in all hydrocarbonous fermentable substances, and also in nitrogenous substances, as we shall see in the next lecture.

Thus, it will be seen that all organic substances, of whatever kind, always give, in fermenting, the same gases, carbonic acid, hydrogen, sometimes carburets of hydrogen, and inert residuums, which are also pretty nearly always the same. Now what is going to become of these residuums? We saw, at the beginning of these lectures, that the duty or function of ferments was to bring back all the materials of organized and living nature to the gaseous state. This duty remains unfulfilled so long as any portion of a substance which they have attacked remains un-decomposed: and this portion is a very important one, for the alcohol, as we know, represents half the weight of the sugar. It is here that we again come across the air-life, or *vie aerobie*, we have mentioned. As the residual substances, or residuums, with which we have made acquaintance, no longer contain any internal heat, they are unimpressionable to airless life (*anaerobie*), but they are not so to life in contact with air, whence they can derive oxygen, and by using this body in a gaseous state, a source of necessary strength and heat. Thanks to air-life organisms (*aerobies*), the various residuums of airless life (*anaerobie*) will in their turn be transformed into water and carbonic acid. Sometimes this will be done in one operation, sometimes in two or more, according to the power of combustion of the intervening microbe.

This action of the airlife organisms will not indeed necessarily be so isolated or so distinct from the action of the ferments as we assumed in our theoretical statement. A mixture will often occur, either when the substance in fermentation exposed to the air, feeds both airlife organisms (*aerobies*) on its surface and ferments in its interior, or when it feeds a single organism, which is at the same time of an airlife and an airless life nature (*à la fois aerobie et anaerobie*).

A few suitably selected examples will give substance to these remarks, and will practically illustrate the process of destruction of an organic mass of any size.

For this, we could not find a better field for study than the following. Here is a hectolitre—or a hundred hectolitres —of beer-wort containing corresponding quantities of sugar, dextrine and nitrogenous matter. Let us seek by what mechanism or process this organic mass will return to ambient atmosphere, by becoming water and carbonic acid. Our next lecture will deal with the question of the nitrogenous matter. We shall only deal here with sugar, and other hydrocarbonous substances.

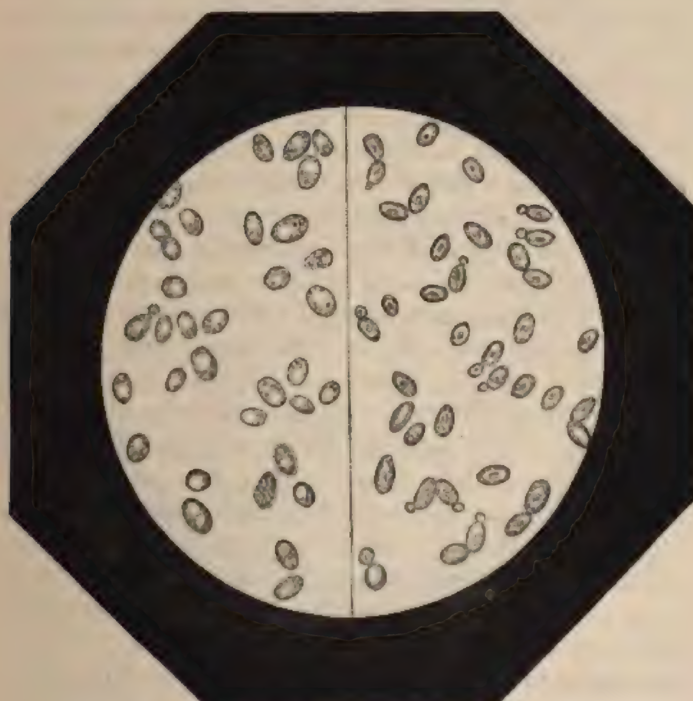
Part of the components of the sugar will first pass into air in the form of carbonic acid during the fermentation which the brewer produces by means of the yeast. I say the yeast, but I ought to say the yeasts: for, in the brewer's vat, there are always several kinds, differing in shape, in the way they decompose the sugar, and in the proportions they give of alcohol and carbonic acid. They are all *aerobies*, i.e. live in contact with air; in other words, they can all be produced in a liquid presenting a wide surface, and of slight depth. They will then completely transform into water and carbonic acid the sugar which they do not use for the construction of their tissues. They can all support an airless life (*une vie anaerobie*), and produce alcoholic fermentation, but they can only do so in a very unequal manner. Some stop when the proportion of alcohol formed is 2 per cent., or even less, and then remain inactive, whatever may be the proportion of sugar still to be decomposed: others go further, and some can raise the alcoholic proportion to 14 or 15 per cent.; but none go beyond this.

Yeasts are therefore of very unequal power, and the result, in every branch of industry connected with fermentation, naturally is to make a selection, and to try to keep as pure as possible the yeast or yeasts which experience has shown to be the most suitable. In the beer trade, for instance, this point of selection has long been settled. With

the exception of a small number of breweries, Burton's for instance, where there seems to be some special kind of yeast, it may be said that, in all the breweries of Europe and America, only the two following yeasts are used :

1. *Low Yeasts.*—They are used in making German and Austrian beer, and, in general, most of those beers known as low beers, not very alcoholic, or nourishing, but of delicate

Fig. 6.



flavour, and remarkably refreshing, the use of which is rapidly spreading on the continent. The fermentation of these beers is always done at low temperature, and, while it is going on, the yeast remains at the bottom of the liquid. Under the microscope, these yeasts look as seen in figure 6. When old, their contents are granulous, there are large internal vacuous cavities, and their shape is slightly

elongated. When young, they are especially recognisable by the fact that the bud formed on the parent globules detaches itself as soon as it has attained the size of the former, and before producing in its turn. Therefore, in low fermentation, the wort only presents to the sight isolated globules, or double globules in a budding state.

2. *High Yeasts.* These are especially used in the

Fig. 7.

manufacture of English beers, whose bouquet and richness in alcohol and nutritive matter render them very palatable at meals. Whereas the low yeasts are generally used at between 5° and 6° C.,—15° to 18° C. are preferred for the others. The disengagement or emission of carbonic acid brings them to the surface, where they form a frothy mass. Microscopically examined, they present the following characteristics; when old, the globules are rounder than those of low yeasts; when young, the liquid is full of

branching chains or chaplets, globules of different generations remaining together to propagate.

Contrary to the opinion prevailing among brewers, these two yeasts are different. Even if the temperature of a low fermentation were to be raised, the beer thus produced would not taste like high fermentation beer, and, inversely, a high fermentation might take place at 5 or 6 degrees without producing low beer; but this is conditional on both the yeasts used being pure. If, as is usually the case, they are mixed in very different proportions, the change in the temperature may give precedence to either, by making it predominate in a mixture where it would have passed unnoticed, and leading one to believe in a transformation of species where there is only a normal evolution, and the substitution of one species for another.

But whatever may be the kind of yeast used, the fermentation which is active at first, gradually slackens. Part of the yeast, the most active part, disappears in the shape of froth, which the brewer collects, as well as he can, by means suited to the purpose, but which cannot be explained in detail here. Another portion—which is more exhausted, remains at the bottom of the receptacles, and can be separated by a decanting process when the liquid has attained the maximum of clearness possible. This decanting, performed in contact with the air, rouses the yeast, gives it a fresh impulse, and causes it to multiply more rapidly; hence a renewal of fermentation, which it is the interest of the manufacturer to maintain, not only until the beer is in the cellar, but in the glass, of the consumer.

The condition to which the beer-wort has been brought by the yeast, is indeed an essentially precarious one. It is true that the sugar, a tolerably complex substance and consequently easy to ferment, has disappeared, and has been replaced by alcohol, a stronger, more resisting substance, incapable, even, as we have seen, of again serving as food for a ferment of the airless life species (*anaerobie*); but there are organisms of the opposite type (*aerobies*) which get on with it very well, and against these the slow

disengagement of carbonic acid, which the brewer endeavours to produce in the barrels he sends out, is a useful means of protection. Moreover, the wort contained other fermentable elements besides sugar, and there remain some in the beer, which have not been affected by fermentation,—dextrine, for instance. There are also, in the beer, the substances produced by fermentation, glycerine and succinic acid, substances which are invulnerable to yeast, but which other organisms can decompose. Any new decomposition that might occur in the beer in its finished state, would do so at the increasing expense of the flavour of the product. What protection is there against such changes?

The slow disengagement of carbonic acid, the presence of a small proportion of alcohol, afford means of protection, but they are slight and insufficient. Keeping in the beer a small quantity of live yeast is also a protection against the invasion of new ferments; for we know that cultivated ground which is already occupied by a healthy plant, resists parasites better than a virgin soil. But the whole of these means of preservation are so hazardous or transitory, that any beer that is at all old may be looked upon as lost. Some spoils in four or five days, some takes two months. That is the only difference.

Let us see how the constituent elements of these delicate beverages are usually affected; and let us begin with alcohol, undoubtedly the most important. Remember that it can only be destroyed by organisms living in contact with air (*aerobies*). This shows at once where its enemies are to be sought. One often notices on the surface of beer left in draught white wrinkled films, which remain unwetted by the liquid, and extend along the sides of the receptacle, as if they had not room enough. Under the microscope, they are found to be composed of millions of oblong globules, like beer-yeast, which, like it, reproduce by budding, but having totally different properties, and whose function it is to convey the oxygen of air on to the matters in solution in the liquids on which they float. This is the *mycoderma vini*, or mycoderm of wine, so called because it also

appears on the surface of the latter. This mycoderm, which as a rule, is a purely air-life organism, or *aerobie*, may temporarily become the contrary, or *anaerobie*, when immersed in the liquid. It then subjects sugar to a real alcoholic fermentation, and it will be seen from figure 8, that the variations it undergoes are slight. But its natural life is in contact with air (*aerobie*), and, then, it not only

Fig. 8.

burns sugar completely, but alcohol, dextrine, and even some of the nitrogenous compounds of beer. It does not attack all at the same time. Its first effect is to burn the sapid and odorous, but unstable, substances to which beer owes its special flavour, and wine its bouquet. It therefore begins by making these liquids insipid and flat. It then consumes the alcohol, and makes it gradually disappear,

which is a further cause of damage. Finally, if it be supplied with the air which it requires, it will burn, sometimes entirely, sometimes stopping at the intermediary of oxalic acid, all the substances in the liquid.

As a rule, it never carries its action very far,—it is not allowed air enough for that,—and its appearance on the surface of beer and wine would, practically, be of no

Fig. 9.

importance, were it not for the fact that it is often accompanied by another and smaller microbe, of an elongated form, contracted in the middle, the *mycoderma aceti*, or mycoderm of vinegar (Fig. 9, sect. 5). This mycoderm is often also found alone, and then it forms a wrinkled film, more delicate and less opaque than that of the mycoderm of wine; but its presence is more serious, because instead of

bringing the alcohol to its extreme degree of oxydation, it stops at the intermediary of acetic acid, an acid to which the palate is very sensitive, and the slightest traces of which are enough to give the beer or the wine a most unpleasant taste of vinegar.

As long as there is alcohol, this transformation continues, the wine or beer getting more and more acid; and this is the way that all the vinegar for consumption is made, or rather ought to be made. But when the alcohol is gone, the mycoderm does not stop; it then concentrates all its burning power on the acetic acid, which it has itself produced, and turns it into water and carbonic acid. The distinctness between these two actions is even remarkable. Thus if, having consumed all the alcohol, the mycoderm is occupied in burning the acid, and more alcohol is supplied, it will leave the acid to attack the alcohol. This deliberate selection of food is not peculiar to the *mycoderma aceti.* I have noticed that it is common to all microbes. They all have some favourite kind of food, which they begin with, and which they only leave when it is getting scarce. The aspergillus niger, living on sugar or starch, for instance, will change part of it into oxalic acid, which it will not touch, at first, and which it will only destroy when the sugar or starch is beginning to fail. But nowhere is the transition so abrupt and so clearly defined as in the case of the mycoderm of vinegar.

When the air-life organism (*aerobie*) has done its work, the result is the same as in the case of the mycoderm of wine: the alcohol has been turned into water and carbonic acid; there has been an intermediary point in one case and not in the other, that is all. As a matter of fact all the alcohol has disappeared from the liquid, and we have also witnessed the destruction of the sugar by, successively, the airless life of the yeast, and the air-life of the various mycoderms.

There are many other ways in which the elements of sugar can revert to the state of water and ambient atmosphere, but we shall meet everywhere with this mixture, this suc-

cessive, or even simultaneous action, of air-life and airless life organisms (*aerobies et anaerobies*). We shall only give one instance, which is of frequent occurrence.

The yeast used as seed for the wort is very often mixed, in small proportions it is true, with a microbe which, morphologically, is very like the mycoderm of vinegar, only somewhat fuller. In Sect. 2 of fig. 9 it is represented mixed with the yeast globules. Yet this organism is not a mycoderm; it lives at the bottom of the liquid, and it gradually converts, weight for weight, the sugar into lactic acid, so called because it is the acid of sour milk. The beer where it develops itself also turns sour, and assumes a taste familiar to beer drinkers. As in the case of alcohol for yeast, this acid cannot be affected by the organism whence it proceeds. But it is capable of transformation by an organism of a purely airless life nature (*anaerobie*), and of undergoing a real fermentation. After, or better still pending, lactic fermentation, there may sometimes be noticed the development in beer, of the plump-looking germs represented in Sect. 3 of fig. 9. These germs are mobile, and they may be seen crossing the drop of liquid under the microscope, with an undulating, flexuous and gentle motion. But for this certain precautions are required: the liquid drop must have been as carefully preserved as possible from contact with air, because air kills, or at all events renders motionless, these bacilli, which constitute the extreme term in the series of ferment cells mentioned in our third lecture. Not only are they able, but they prefer to live without oxygen, and they would not be able to survive a protracted contact with air, were it not for the shelter afforded by their spores. Hence they are ferments, and powerful ones.

With sugar or lactic acid, they disengage hydrogen and carbonic acid; they, moreover, render beer slightly putrid, and we shall soon see why. Lastly, they give it a very disagreeable taste, by substituting for the sugar or lactic acid which they destroy, an acid identical with that of rancid butter, viz. butyric acid.

This acid, in its turn,—which is the residuum of an airless life organism (*anaerobie*)—is, like alcohol, a product for the destruction and gasification of which the contact of air is necessary. Hence the appearance, as its destroyers, of various mucedinæ, among which the penicillium and the aspergillus of Fig. 5 are conspicuous.

Thus, here is another case where the efforts, either combined or separate, of airless-life and air-life organisms have led to the complete destruction of sugar; we might find others, by continuing our examination of the various processes of decomposition of the components of wort or beer, that is to say, the diseases to which these liquids are subject. For instance, when beer becomes *oily* and *slow in flowing*, it is because its sugar and its dextrine are under the influence of a micrococcus disposed in long rows, as seen in Sect. 4 of Fig. 9: In the same way, Sect. 7 represents a microbe in couples or singly, which is present when the beer has that taste of green fruit, accompanied by a peculiar smell, which brewers dread so much, in certain countries and at certain seasons. In Sect. 1 are represented the filaments of the alteration—much more frequent than the last—which is known as *turned beer*.

But it is needless to go further. The general process of the destruction of a given quantity of beer-wort has now been made clear. The airless life organisms (*anaerobies*) begin the work, the air-life organisms (*aerobies*), continue and complete it. It is true that, in destroying the organic matter around them, they create fresh matter in their tissues, But this new matter, which in weight is much less than the first, is, like it, a prey to ferments other than those whence it proceeds; and it thus happens that, what with certain microbes living on the original organic substance, and others on the substance of the former, there soon remains, as residuum, nothing but water which the air imbibes, mineral substances which the soil preserves, and intangible germs which the wind carries away to begin elsewhere, a new life.

LECTURE VI.

NITROGENOUS NUTRITION OF MICROBES.

Summary—Successive stages of organic matter in course of decomposition—Intervention of diastases—Digestion in microbes occurs in the same way as in the higher animals—Description of the struggle between microbes and the normal cells—Consequences relating to the theory of vaccine, and therapeutics.

In the examination we are about to make of the azotised alimentation of ferments, will recur the principal characteristics of the one we have just concluded, viz. the intervention, either simultaneous or successive, of airless life and air-life organisms (*anaerobics et aerobies*), for the destruction of organized matter. In a dead body left to itself, the first to set to work are the "*anaerobics*" or organisms not requiring air. During life, these occupy the intestinal canal, sometimes, I have found, penetrating to a certain depth in the excreting canals of the digestive glands. As soon as death occurs, they begin their work by liquefying the tissues around them, and gradually penetrate into all the organs, where they produce disengagements of gas, thus causing the body to swell, and the formation of ruptures of the epidermis, or fissures, through which the other microbes, those which require air, and which have hitherto been stopped by the resistance of the tissues of the skin, are enabled to penetrate, in their turn, and put their powers of combustion into action. The final result is, again, a purely mineral residuum, all the organic matter having been turned into gases, which have been carried away by the air, or into substances, which have been dissolved by water.

But if the broad lines of this investigation do not teach us anything very new, we will find some new facts by going into

details, by examining the series of successive degradations which nitrogenous organic matter undergoes in passing from its organized state, when in our tissues, to the gaseous or liquid state, in which it will be ready to form new ones. The residual products left by the action of ferments on sugar are few after all, because sugar is a simple grouping of a small number of elements. But the elements of our tissues are far more complex than sugar, and the remnants of their separation, their residual products, are therefore far more numerous than in the case of hydro-carbonous substances. Although we do not possess any very profound knowledge of this subject, for we are now as it were on the confines of Science, still it is necessary to get a general idea of it.

The essential characteristic of the nitrogenous organic matter in the body of living creatures or organisms—albuminoid matter, to call it by its scientific name—is to be pretty nearly insoluble in water. This alone enables it to serve to constitute our tissues, which are continually steeped in liquid matter. Such, for instance, is the fibrine of our muscles. The albumen of eggs, the fibrine of blood, the caseine of milk, would seem, at first sight, not to come within this rule, and to be in solution in water. But this solution is only apparent. It is like the gelatinisation obtained by boiling a little starch in a large quantity of water. The result is a real liquid, where the starch seems to have as completely dissolved as a piece of sugar would. This is not the case, as we know now; the starch is merely in a state of suspension, and can be separated by means of a suitable filter, whereas the whole of the sweetened water would pass through. In the same way, a filter will retain the caseine of milk, and the albumen of eggs, and these substances exist in water in flakes which are more delicate but quite as insoluble, as muscular fibrine or cooked albumen. Besides being thus very nearly insoluble in water, they are absolutely so in alcohol.

Such is their initial or original state. Their first step in the course of destruction will make them soluble in water.

In a living organism, there are always some that have reached this stage. The word *life*, as we have seen, is synonymous with a continual changing of tissues, and in order to be eliminated, the substances of these tissues should be capable of solution. Thus the juice of meat contains many of these retrograde products, to which broth is indebted for such nutritive qualities as it possesses. Notwithstanding their importance, we do not yet know much about these products; we will generalize them under the name of *extract soluble in water*.

Another step backwards towards destruction, and they become an *extract soluble in alcohol*. Here, the transformation of the initial molecule is certainly greater, though it has not yet succeeded in eliminating all the characteristics of the albuminoid matter. Our extract soluble in alcohol does not yet appear in a crystalline form, but remains stubbornly amorphous, and does not unite intimately with any of the chemical bodies. It still preserves a complex structure, which besides carbon, hydrogen, oxygen, comprises small quantities of sulphur and phosphorous, whose functions in fermentation we shall soon witness.

The proportions of these constituent elements are only different from what they were at starting. On an average, the proportion of oxygen has become greater, and that of the others less, just as if there had been oxydation, or, what nearly comes to the same thing, analytically, the addition of one or more molecules of water. But, fortunately, we need not enter into the essence of this transformation: all we have to do is to deal with the result. Now this result is, unquestionably, to have taken us further away from the initial form than we were with the extract soluble in water.

Below the extract soluble in water, now begin to appear crystallisable substances, *leucine*, recognisable by its iridescent lustre; *tyrosine*, whose name recalls its discovery in cheese; *glycocolle*, or sugar of gelatine; *butalanine*, and various alcaloids analogous to those physiologically produced by poisonous plants. Below these again we have

products whose simplification has been carried far enough to make them begin to become volatile—such as *phenol* or *phenic acid*, *indol* and *scatol*, to which the excremental matters owe their peculiar odour. After these come volatile acids, or stable acids of a very simple form, like those we met with in the case of hydrocarbonous substances, viz., acetic, butyric, valerianic and oxalic acids ; only here, instead of being free, as in the case of sugar, these acids are combined with plain or with compound ammonias, which themselves are the last residual product of the azote that was originally in the organic matter. Finally, at the last stage, we find gases, of which the essential formation is carbonic acid, hydrogen, sometimes nitrogen, and sometimes also various carburets of oxygen, among which marsh gas is conspicuous—we may guess why. When formed in a medium where oxygen prevails, where, for instance, air-life organisms (*aerobies*) exist, these gases are pure and consequently, inodorous. But when they proceed from the action of ferments that live without air (*anaerobies*), and are formed in a reductive medium, deprived of oxygen, the sulphur and phosphorus, which we mentioned just now, are affected by the hydrogen that is disengaged. There occurs a formation of small quantities of sulphurous and phosphorous hydrogens, which impart to the mixture a well known putrid smell. It is then—and only then—that people say, in familiar terms, that there is putrefaction. They go still further. Putrefaction is so common in the decomposition of nitrogenous substances, that when there happens to be no putrefaction it is assumed that these substances are intact, and, if of an alimentary nature, that they may be consumed with impunity.

Science, as we have seen, is unable to accept such an assumption, which is a hasty and sometimes a dangerous one. The production of odorous gases is a secondary item in the life of microbes, which, with the same living species, may or may not occur, according to circumstances ; and because, when observed, it indicates the presence of ferments, it does not follow that when it is not observed

there are no ferments present. The only judge is the microscope.

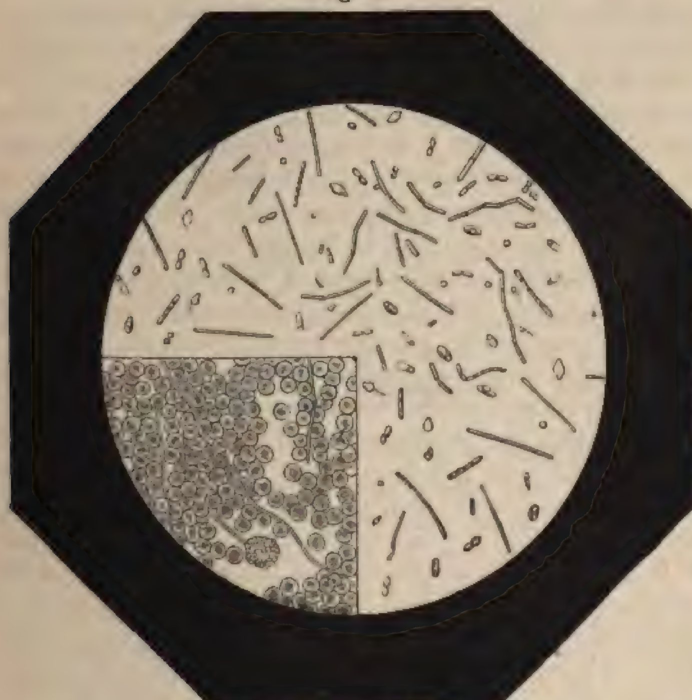
Let us return to our starting point. We know now the various degrees in the scale of degradation through which albuminoid matter must pass in order to resume entirely a gaseous state. Let us see through what course its various ferments will lead it. After what we have learnt about sugar, we may expect to see, almost at every step, special microbes appear, in greater numbers than with hydrocarbonate substances, the degrees being more numerous, but each of which will take up the nitrogenous matter at a certain stage, will carry it down a few degrees, and will then deliver it to another living species. Such is what experience shows to be the case. The destruction of an organic mass calls for the efforts of a great number of different microbes, some of which are ferments and live without air (*anaerobies*), acting, in preference, on the most complex substances, and others which require air (*aerobies*), and are alone capable of eliminating the most simple substances, and completing the work commenced by the former.

In this series of microbes possessing different properties, the only ones whose examination can add to what we already know, are precisely the former, those whose food, fermentable matter, is the albuminoid substance itself, in the state in which it exists in the living world. By what process will this substance, insoluble in water as we have seen, be able to penetrate through the sides of the cell of the microbe to become a source of nourishment and production for it?

Here is, for instance, an active agent in the liquefaction of the tissues, where it fixes itself, viz. the vibrio of septicæmia or septic vibrio, Fig. 10. It can live in the muscles by assuming the short, compact shape represented in the figure, and under certain conditions, it will exercise upon them a putrefying action which is revolting. It can also live in the blood, by taking the form of the long threads depicted in one of the quadrants of the plate, and yet, as we

said, this blood, notwithstanding its liquid appearance, only contains solid alimentary substances. How is it that this muscle and this blood become food for the microbe? They are so for the higher animals at the expense of a preliminary transformation caused by digestion. Do microbes also make them undergo digestion? Let us examine this point carefully. We shall be able to deduct

Fig. 10.



therefrom a complete assimilation between the nutritive processes in the world of ferments, and in the other.

Where this assimilation is the clearest, is in the digestion of milk. Without one exactly being able to know why, this digestion is always preceded by a coagulation, and this coagulation, in its turn, takes place by a process which differs in the adult animal, and in the sucking animal. Let us examine these various phenomena separately.

In the stomach of the adult animal, the coagulation is produced by the acid gastric juice which the milk encounters there; for caseine is insoluble in acid liquids: and this is why it is also precipitated when milk is in contact with the *lactic ferment*, of our last lecture. But this is only a chemical action; as yet there has been no act of digestion.

In the stomach of the sucking animal, the process of coagulation is quite different. There the milk encounters a peculiar secretion, called rennet, which curdles the milk without in any way making it acid, and which has been used, for this purpose, from time immemorial in making cheese. This rennet is usually derived from the mucous of the fourth stomach of ruminants, and has become a commercial product of some importance. Now, it is found with all its characteristics, in the products of secretion of microbes that live on the caseine of milk, whose first action is to coagulate that liquid. Consequently, the starting points of the digestive phenomenon are identical.

For as yet we are only at the starting point. Coagulation is nothing but an agglomeration, a massing of the elements of caseine, which at first were scattered singly in the liquid: as yet the milk has not been taken a single step towards digestion; on the contrary. Neither rennet or gastric juice exercise any ulterior action on the clot that has been formed. It is a necessary consequence that the stomach should be unable to digest milk; and for this very reason affections of the stomach are often cured by means of milk as the sole food. The stomach recovers, because it gets rest. In the process of digestion it is the pancreas alone that acts.

For this, it secretes a diastase, which I have discovered, and named *casease*. Under the influence of this secretion the milk gets discoloured, assuming the tint and transparency of slightly turbid broth, and the caseine loses its property of precipitation by acids. Well, it happens that the ferments of the caseine secrete the same diastase, in quantities that are comparable with the cells of the pancreas, and thus display a digestive activity which is not

only of the same nature, but is also of the same power, as the digestive cells in the upper animals.

So much for caseine; but it is certainly the same also, though the question has not been closely examined, for fibrine, albumen, and the other albuminoid substances. Hence, we may safely generalise the question, and draw from it a double conclusion.

The first of these conclusions is, that the digestive canal being constantly filled with microbes at work on the alimentary matter it also contains, there is constantly going on within us, the superposition of a microbe-digestion and a normal digestion. The process of these two digestions is the same, they give the same results, and may therefore, to a certain extent, take each other's place. Moreover, I have found that their power is usually the same.

Our second conclusion is still more worthy of interest, but it requires a little more developing. Let us suppose, for example, that, either voluntarily or involuntarily, two cells are placed together, on any point of the tissues of a higher animal, one of the cells being a normal one, viz., that of the tissue, and the other belonging to a microbe. We have seen that these two cells possess the same external structure, the same chemical composition, and the same vitality. We have just found that their requirements, and their means of satisfying them are the same; so is their food, and their mode of transforming it. The various products of the degradation of the albuminoid matter that may be derived from a piece of muscular flesh are identical with those that may be found in a quantity of milk which microbes have transformed. What will result from all these points of resemblance, with regard to the cells we have brought together? The result will be that they will impede each other, that there will be a contest. One of them is supported by the whole organism on which it depends, and from which it sometimes derives strength, and also, alas, sometimes weakness. The other has its youth, and its immense power of reproduction. A priori, the struggle is always a doubtful one.

Fortunately, if the requirements are the same for the two

cells, the power to satisfy them may vary considerably; and now is the time to remember the curious facts taught by our fourth lecture, where we saw on what infinitesimal quantities of a useful or noxious element might depend the fruitfulness or the degeneracy of microbe cultivation. This question of infinitely minute creatures—appearing as it does in a question of biology—is of the greatest importance; for it shows that the result of the contest between our two cells may depend on an imperceptible circumstance, on something almost outside the limit of our investigations. Remember that chemical reagents are almost powerless to detect, in a liquid, the amount of salts of silver that will kill an aspergillus. But however remote—in the order of measurable amounts—may be already this influence on which depends victory or defeat, we are at liberty to carry it back still further as may be easily shown. In Raulin's liquid, an invisible trace of nitrate of silver is enough to arrest the implantation of aspergillus. Is it not evident that if, to the action of the salt of silver were added another influence likewise hostile to the plant, the dose of poison, already so slight, might be still further reduced? Now, that is what occurs in organism. Independently of the repressive influences that may result from the physico-chemical state of the medium, the parasite is opposed by the normal cells. For a long time, at first, as testified by the duration of what is known as the "incubation" period of most virulent diseases, the struggle takes place on equal terms. The parasite is then, at the point of inoculation or of attack, laboriously fighting its way, violently opposed by a contrary force. If I may use the comparison, it is as if two exactly similar weights were placed in a pair of scales. The slightest pressure on one side will incline the scale that way. From that moment, the equilibrium, instead of returning, as in the case of ordinary scales, will become more and more disturbed, to the benefit of the lower scale, because every advantage obtained by one of the combatants will increase his strength, and diminish that of his opponent.

We may conclude that, at first, the cause of the victory

or defeat, of the illness or recovery, may have been a totally insignificant circumstance, the effect of which would have passed quite unnoticed, had it not been for the presence of the parasite. How is it possible, after such a conclusion, to avoid thinking of those noxious influences to which medicine so often appeals, and which it sometimes looks upon as the sole agents of some diseases, cold, heat, damp, crowding, physiological misery. Is it not evident that, though incapable of producing a virus, they may sometimes promote its development in an organism where it existed, but where it had hitherto met with a resistance superior to its strength?

We have just witnessed in its details the contest to which we have sometimes referred in the course of these lectures—between a living organism and the pathogenic microbes. This may now help us to understand the existence and the properties of vaccines, that is to say, of microbes of slight virulence, the inoculation and development of which in the organism may preserve the animal in which they are from a fresh implantation of similar, but more virulent microbes, and consequently save it, by means of a mild form of illness, from a serious or mortal disease.

Now, theoretically, what will be necessary to transform a virus into vaccine? It will be necessary to imperceptibly diminish its vitality, so that it should reach the organism in an attenuated form, and thus furnish to the normal cells, which would inevitably be defeated under ordinary circumstances, means of resistance to continue the contest without succumbing, and to await the time when the parasite, having altered, to its own disadvantage, as they all do, the composition of the medium which it has attacked, shall disappear therefrom, expelled by the now victorious normal cells. There, in a few words, is *a theory of vaccines.* I do not say it is a complete one, for it evidently requires a premiss, viz., the maintenance of the original attenuation in the cultivation of the vaccine in a vaccinated animal. Nor do I pretend that the theory has been demonstrated;

but I maintain that it is a plausible one, because there is not a single one of its deductions that we could not support by facts demonstrated in these lectures. It even gives us the key to the most usual processes of making vaccine, the action of air and heat (M. Pasteur), or the action of heat alone (M. Chauveau): for have we not seen, from these lectures, that oxygen and heat will produce diminutions of vitality of the same order in microbes?

And now a final step. These investigations, which are now drawing to a close, have, at every minute, as it were, been the means of opening to us vast horizons on the question of hygiene. We have just obtained therefrom a general prophylactic or preventive of virulent diseases by means of vaccination, a prophylactic the mystery of which we have endeavoured to unravel, and the value of which has been practically demonstrated(*). Might we not also arrive at some system of rational therapeutics for those diseases, the most formidable that humanity is subject to?

In other words, might we not try to intervene in this contest between the normal cells and those of parasites, by stimulating the energy of the former, and repressing the vitality of the latter? We know that for this the slightest effort will suffice, especially at the outset. The smallest weight in the scales will ensure a definitive destruction of equilibrium.

If these cells, both normal and parasite, happened to have exactly the same wants,—the same friends, and the same enemies,—the problem would be an impossible one to solve; we could not favour some, without favouring the others. But fortunately this is not the case. Experiments in inert vases, with the liquids used in the laboratory, show that each microbe, so to speak, has its stimulant, and its antiseptic,—what might be called its *zinc* and its *silver*, to

* The records in M. Pasteur's exhibit show that on the 30th April, 1884, there were: 852,200 sheep, 94,800 oxen or cows, and 4,100 horses vaccinated against carbuncle; 4,500 pigs vaccinated against "rouget," or pig-plague; 1,950 fowls vaccinated against fowl-cholera, and about 80 dogs vaccinated against rabies. These figures need no comment.

borrow a simile from what we have learnt about the *aspergillus niger*. Everything indicates, although Physiology has not made much progress in that direction as yet, that it is the same for the various cells of the organism.

Assuming that we know, in the case of the normal and parasite cells, as we do in the case of the *aspergillus niger*, the physical or chemical conditions of existence or vitality, the influence of the degree of temperature, the nature and the dose of useful or injurious elements, etc., the therapeutical problem of any virulent disease is reduced to seeking which of these conditions, favourable to the organism, and unfavourable to the microbe, should be made to intervene. The problem has been scientifically set ; that is to say, there is an object, and a means of attaining it. The remainder is a question of time, of patience, of careful research,—qualities which usually are not uncommon among savants.

My task is over, for my object has been attained. I wished to reach to the limits of modern science : to show on the one hand, the distance traversed, and on the other, the vastness of the horizon before us. I trust that both prospect and retrospect may prove to be equally seductive, and that the sight of the progress accomplished may inspire the boldest with courage to push forward, and the others with sympathy for those brave pioneers, and confidence in their success.

PUBLIC HEALTH LABORATORY WORK.

BY

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Part I.—BIOLOGICAL LABORATORY.

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WITH

CATALOGUE OF THE EXHIBITS IN THE LABORATORY.

PUBLIC HEALTH

LABORATORY WORK.

I.

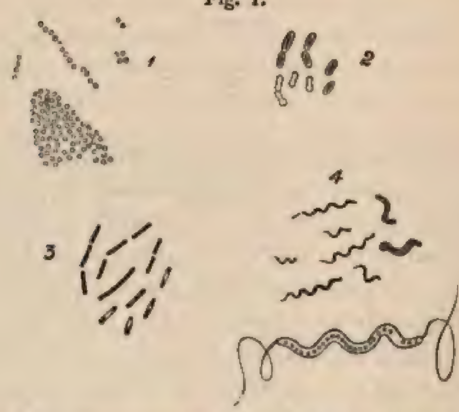
It has of late been shown that in a considerable number of infectious and contagious diseases, minute living bodies are present of various shapes and characteristics, which have in some instances been shown to be the cause of the disease. These bodies belong to the lowest class of plant life and are termed Schizomycetes, because at first they were only supposed to multiply by division or fission, as it is technically called. The most common names for this class are, however, Bacteria or Micro-organisms. There are four well-marked groups of bacteria, divided according to differences in form. These are (1) Bacteria proper, small oval or slightly elongated bodies; (2) Bacilli or rod-shaped bodies; (3) Micrococci or round bodies; and (4) Spirochætæ or spiral bodies.

Many of these micro-organisms can move actively in fluids, their progression in most instances being probably due to the presence of a lash or cilium at one or both ends. This has been demonstrated to exist in the bacteria and in some forms of Spirilla (belonging to the fourth class). Movement also is present in some of the bacilli, but the majority of those associated with disease are motionless. In most cases moving bacteria have a motionless stage. The spontaneous movements of these bodies are sometimes

difficult to distinguish from the well-known molecular motion of minute particles suspended in fluid. The former is, however, as a rule, well marked, the organisms changing their place either with a swift darting or slow undulating movement; while the latter is a dancing, or in the case of rods an oscillating motion without change of position.

The mode of growth is in most cases by division. A rod elongates and soon divides transversely to its long axis, giving the appearance of two rods joined together by their ends; these rods separate, and we have thus two individuals. In the case of the micrococci the division may take place

Fig. 1.



1. MICROCOCCI AND STREPTOCOCCI; 2. BACTERIA; 3. BACILLI; 4. SPIRILLA.

not merely transversely but longitudinally, and thus we may have pairs of micrococci or triplets, or fours, or groups; or it may take place in one direction only, giving rise to long chains. In the last case the organism is called a chain micrococcus or streptococcus. The rapidity of growth of bacteria depends greatly on the temperature and on the nature of the soil; but it has been calculated with regard to one or two forms grown on suitable soil at the ordinary summer temperature of this country, that they double their numbers at the least once in an hour, so that every individual produces 8,388,408 in 24 hours.

Not only does growth occur by fission, but it also takes place, more especially in the bacilli, by the formation of spores, (see figs. 1, 3). These appear in the rods as bright refracting, round or oval bodies, the rod after a time disappearing and liberating the spores.

These spores are of great importance, as they are extremely resistant to the action of heat and chemical agents. They may retain their vitality for years in the dry state, and grow again into the fully developed organism if placed in suitable circumstances.

Ever since the discovery of these organisms till within the last few years there have been constant and often violent discussions as to their origin, some asserting that they were always derived from a parent, others stating that they arose *de novo* in organic fluids from aggregation of organic molecules, which became vivified as the result of various physical causes—the theory of spontaneous generation Abiogenesis or Heterogenesis. The latter theory has been gradually disproved step by step till it is now no longer upheld, and there can be no doubt that whenever micro-organisms develop they have been derived from one which has come from the air, water, or surrounding objects. The fallacy arose from the fact that, when an organic fluid such as infusion of meat, was placed in a flask, boiled and the flask hermetically sealed, in a certain number of instances the fluid became turbid from the development in it of these minute bodies. As boiling a fluid for a few minutes was supposed to be destructive of all existing life, a positive result was held to be proof of the origin of these bodies *de novo*. Sometimes the fluid was boiled after the flask was sealed and the temperature was raised above 212° Fahr., and yet in a number of instances development occurred. The fallacy in these experiments is two-fold; in the first place the upper parts of the vessel were not sterilised previous to the introduction of the fluid, and in the second place nothing was at that time known of the existence of spores. The introduction of the method of first heating the flask for some hours at a temperature of

at least 300° F. after the orifice had been plugged with cotton wool, taking care in the introduction of the impure fluid that it does not touch the upper part of the vessel, and then boiling the fluid for ten or fifteen minutes, was followed by a very great diminution in the number of instances in which development afterwards occurred in the fluid. And when it was shown by Tyndall that, if the fluid, instead of being boiled only once for a long time, were boiled on several successive days for a few minutes at a time, no instances of development occurred, the last blow was struck at the theory of spontaneous generation, and it may now be finally dismissed from consideration. Tyndall made the brilliant deduction from his observation that some of these bodies must form very resistant spores, and his object in boiling the fluids more than once was to give time for the spores not killed on the first occasion to develop into mature organisms, when they are readily killed by the second or subsequent boilings. This deduction, made before the spores in these organisms had been observed, has now been amply confirmed by microscopical observation. At the present time it is perfectly easy to maintain any organic material pure for an indefinite time if the vessel in which it is placed be sterilised at a high temperature for some hours after being plugged with cotton wool, if care is taken to introduce the fluid to the bottom of the vessel, and if the fluid be afterwards heated for an hour for two or three days in succession to a temperature even a good deal below the boiling point of water.

These organisms and their spores are found almost everywhere in nature in enormous numbers. They float in the air: in large numbers in the air of factories, towns, and inhabited rooms, in woods and forests; in smaller numbers in the air in the open country; still fewer at high altitudes; and in the air on the glaciers in Switzerland, for example, they are almost if not entirely absent. They are constantly present in water; the more stagnant the water is, the more numerous they are; they pass through the ordinary filters, and are, therefore, numerous in drinking

water. The surface of the animal body is covered with them, and in the mouth and parts of the alimentary canal they flourish in great luxuriance. All dust contains them, and the soil is the special habitat of many forms of the greatest importance in the plan of nature.

These organisms play a very important rôle in nature, and without them vegetation and with it animal life would greatly diminish if not entirely cease to exist. They are the mechanism by which dead vegetables and animals are decomposed and rendered suitable food for future generations of plants. The higher plants derive their carbon almost entirely from the carbonic acid of the air, and their nitrogen in part from the ammonia of the air and soil, and in part from nitrites and nitrates in the soil. By the combined action of the chlorophyll and the sunlight the carbon is extracted from the carbonic acid and used to form the complex organic substances of which the walls and contents of the cells of plants are composed. In the same way, also, the nitrogen must probably be in its elemental form before it can be utilised. The higher plants cannot take up complex chemical substances and utilise them as food; these must first be reduced to their simple forms. Hence, there must be some mechanism for reducing these compounds to their simple forms, otherwise the higher plants would perish for want of suitable food. Part of this destructive work is done by animals. They can take up these complex substances and utilise them as food, and, as a part of their vital action, they reduce a portion of them to carbonic acid, water, and other simple forms, in the lungs and throughout the body. But the reduction of these substances by animals is very imperfect and quite insufficient for the purpose, while, further, the dead animal body must be itself converted into these simple elements, otherwise a large amount of energy and nutritive material would be constantly lost. This gap is filled up by the lowest forms of plant life—the miscroscopic fungi, but more especially the bacteria; their existence is therefore essential for the maintenance of all life.

It must not, however, be supposed that every bacterium is capable of taking up a complex organic substance and splitting it into its elementary constituents. All take up oxygen either from the air or from the substances in which they grow, and probably all produce more or less carbonic acid, but some are only able to carry on the destructive process to a certain stage, and when their work is done other forms come to their aid and complete the change. Among these partial changes in organic substances, as the result of the growth of micro-organisms, we have the great class of fermentations which result in the production of some of the essential elements of food and many of the so-called luxuries.

There is one class of micro-organisms which gives evidence to the naked eye of the change they occasion in the material in which they grow. These are micro-organisms which produce various pigments. There are now a large number of pigment-producing organisms known. Among the torulæ there are some which produce pigments of various colours. The best known of these is one which forms a pink substance (Rosahefe). This substance only becomes pink at the surface in contact with oxygen; at the deeper parts of the growth, the material formed is colourless, but rapidly becomes red when exposed to the action of the air. In none of these cases is the micro-organism itself coloured, but it is the material produced by and surrounding it that has the property of absorbing certain portions of the spectrum. Other forms of torula produce other colours; for example a yellow torula is very common. Among the subdivision *bacterium* of the Schizomycetes there are a few which produce pigments. Chief of these is one which causes the greenish-blue colour which is sometimes seen in pus; also one which produces the so-called yellow milk, and one which gives rise to a brown colour. It is necessary to mention here that it is not only in pus or in milk that these respective colours are produced. Pigment micro-organisms always produce the same colour on whatever soil

they grow, provided that the soil possesses the necessary chemical substances. And the same pigment is always produced by the same organism. An organism cannot at one time produce a red, at another a blue, at another a yellow substance; it always produces the same colour, or where the soil is unsuitable, but where it is still capable of growth, no colour at all. There are very few *bacilli* which cause the formation of pigments, but of these the best known is the bacillus of blue milk. These bacilli can be cultivated apart from milk, and when introduced into a glass of milk which is becoming sour, but has not yet coagulated, they produce this blue change. A red pigment is also produced by a bacillus—*Bacillus ruber*. By far the largest number of these pigment-producing organisms belong, however, to the class of *micrococci*. These grow with great readiness on boiled potatoes, and also on various gelatinised organic infusions. One of the best known is *Micrococcus prodigiosus*, which gives rise to a beautiful blood-red colour. Among other colours produced are a yellow (*Micrococcus luteus*); an orange-yellow (*Micrococcus aurantiacus*); violet, green, &c. These pigment organisms are very important for experiments on the specificity of these minute bodies, and also, as will be seen later, for testing the power of various agents in destroying the vitality of these lower forms of life.

The changes produced by the other micro-organisms associated with fermentation are not so evident to the naked eye as those we have just been considering, but nevertheless it is possible to render these changes visible in some cases. For example, when most forms of bacilli grow in an organic fluid rendered solid by the addition of gelatine, this solid material becomes fluid as the result of the action of these bacilli on the gelatine. The fluidity of the gelatine is at once a test of the presence of bacilli, and an evidence of the extensive chemical alterations they produce in the soil in which they grow. I may mention a beautiful example of a chemical change rendered visible to the naked eye which occurred to me lately. A yellow torula

was being cultivated on a gelatinised meat-infusion which contained a minute quantity of blood-colouring matter. In the preparation of the material, the blood-colouring matter had been converted into methæmoglobin, a substance convertible into oxyhæmoglobin by the action of oxidising and reducing agents. On one occasion, in re-inoculating this yellow torula, a bacterium became mixed with it; the cultivation was impure. After these two organisms had grown on the gelatine for a few days, it was found that the material beneath the yellow patch, and extending far beyond the growth of organisms, had assumed a delicate pink colour, which on spectroscopic examination was found to be due to the presence of oxyhæmoglobin. Re-inoculations of this bacterium on similar soil was always followed by the same result, the bacterium evidently producing a gaseous reducing agent which passed a certain distance into the gelatine, and converted the methæmoglobin into oxyhæmoglobin. That the growth of bacteria is followed by changes in the soil in which they grow is also easily ascertainable by chemical analysis, and among the most important of these changes are the various fermentations which occur in organic substances.

The most extensive fermentation caused by micro-organisms is the conversion of glucose and maltose into alcohol, carbonic acid and other substances. This is brought about by the growth of the *Torula cerevisiæ* in solutions containing these substances. Other torulæ and also some fungi are capable of causing the conversion of sugar into alcohol, but their effect is insignificant as compared with that of the organism employed for the purpose—the *Torula cerevisiæ* or yeast plant. The torulæ are small microscopical cells, round or oval, with cell wall, granular protoplasm, and sometimes vacuoles. They grow by budding, and in some cases by the formation of spores. They grow with great rapidity in suitable sugary solutions if exposed to the air. When there is plenty of free oxygen present they do not cause much fermentation of the fluid; but if the supply of oxygen is insufficient, they grow less

luxuriantly, but produce a much greater change in the constitution of the fluid. In these circumstances they are supposed to take oxygen from some of the compounds in the material in which they grow—probably from the sugar which splits up chiefly into alcohol and carbonic acid, a small quantity of glycerine and other substances being also formed.

Many other fermentations are caused by the Schizomycetes. Thus the souring of milk is due to the growth of a small bacterium, the *Bacterium lactis* (Lister) in it. This organism can be cultivated pure in solutions other than milk, and when again inoculated into milk, the latter becomes sour and coagulates from the formation of lactic acid from the milk sugar. The butyric acid fermentation has been shown to be due to a bacillus, which only grows in the absence of oxygen, and indeed is killed by it. When cultivated in various fluids, even in Pasteur's solution, it causes the butyric fermentation. This organism is of use in the preparation, especially the ripening of Swiss cheese. It grows and causes the butyric fermentation during the first twenty-four hours, while the cheese is still under the press, and the fermentation is accompanied by the evolution of large quantities of gas. The slower development of this gas which occurs later explains the formation of cavities in the cheese. The chemical change consists in the partial transformation of the milk sugar into butyric acid. Sugar at times undergoes a viscous fermentation. This is the transformation of sugar into gum, mannite, and carbonic acid, and results in the formation of a viscid ropy fluid. This fermentation is due to micro-organisms, said to belong to the class of micrococci. Putrefaction is a fermentation accompanied by the development of a foul smell, but is a much more complex process than the other fermentations, and is probably caused by several organisms producing a succession of fermentations. This fermentation is a very important one, as during its course products may be formed which are intensely poisonous to animals, and introduced into the circulation may cause symptoms resembling those

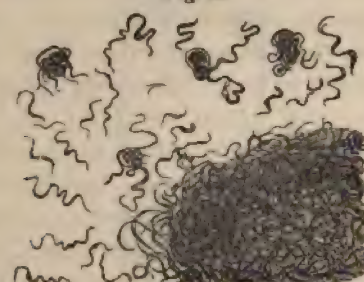
due to various alkaloids. The acetic fermentation is due to a small bacterium which converts alcohol into acetic acid. The growth of this bacterium only occurs when suitable nitrogenous and other nutritive substances are present and when the fluid does not contain more than ten per cent. of alcohol.

Other fermentations are associated with bacteria, and though not yet thoroughly worked out are undoubtedly due to them. The old idea that organic substances underwent fermentation and decomposition owing to the action of the air or other causes independent of the growth of these bodies, has been shown to be erroneous, for the most diverse organic materials may be kept for an indefinite time with suitable precautions without the occurrence of any change in them. Thus, milk may be taken from the cow with certain precautions, received into a sterilised flask, protected from the dust by a cotton wool cap, and kept for an indefinite time without undergoing any change and without the development of any organism. In the same way blood or portions of the organs from a healthy animal just killed may be placed, under similar arrangements, in vessels, and kept indefinitely, without decomposing. These experiments show not only that organic substances do not undergo fermentations if micro-organisms are absent, not only that bacteria do not originate spontaneously (i.e. without a parent) in organic substances, but also that bacteria are not present in the blood or tissues of a healthy living animal. This is a point of great importance.

Many of these micro-organisms will only grow on particular soils, while the great majority will grow on any albuminous substance. The necessary substances are water, carbonaceous and nitrogenous organic substances, and various organic salts, especially phosphates and salts of potash. One of the most important points with regard to the soil is the reaction, most bacteria requiring a neutral or slightly alkaline substance. This is, however, not invariably the case, as for the bacterium which causes the acetic fermentation, for example, an acid soil is requisite. Again, bacteria as a rule grow best in the presence of plenty of

oxygen; but there are some which will not grow unless oxygen is almost or entirely absent. Some of those which cause fermentation do so most vigorously in the presence of free oxygen, others act best when there is no oxygen, where, therefore, they must take their oxygen from the substances in which they grow. The temperature is also a point of great importance, a medium temperature of 60° to 80° F. being best for most forms. The best temperature is, however, different for different forms, some, for example the bacillus of tubercle, only growing at the average body temperature.

Fig. 2.



SURFACE OF COAGULATED BLOOD SERUM ON WHICH THE BACILLI ARE GROWING. × 100.

When growing on solid substances, such as gelatinised meat-infusion many forms of bacteria show distinctive characteristics in their mode of grouping, &c., and thus may be distinguished from one another, though this would be hardly possible under the microscope. Thus the *Bacillus anthracis* grows in a loose network, the rods not being closely applied to each other; the bacillus of tubercle grows in dense masses of parallel rods, which soon become more or less S shaped (see fig. 2); the bacillus of septicæmia in mice forms an extremely delicate cloud; the micrococcus of pneumonia forms pin-shaped colonies at the point of inoculation (see fig. 3), and so on. Thus by the naked eye one can pick out many organisms by their mode of growth or solid substrata.

Not only are these microscopic plants essential in nature,

by causing fermentation and decomposition of the substances in which they grow, but some forms can also prove injurious to vegetable and animal life. Those which injuriously affect plants belong almost solely to the class of fungi, while of those which are hurtful to animals only one or two are fungi, the great majority being various forms of bacteria.

Fig. 3.

APPEARANCE OF CULTIVATION OF THE MICROCOCCI OF PNEUMONIA (FRIEDLAENDER) ON GELATINE. (NATURAL SIZE.)

These bacteria may be hurtful by the production of poisonous substances which belong to the class of alkaloids, and are rapidly fatal to life in a sufficient dose. If a quantity of putrid blood be injected into a number of mice, for example, a certain number may die only after a day or two or may not die at all ; but where the quantity injected

is large the animals may die in a very short time (a few hours), as the result of the absorption of the poisonous substances resulting from the growth of the micro-organisms in the putrefying blood. Some observers state that they have been able to extract from this putrefying blood an alkaloid substance, which, injected into animals, produces the same poisonous effects as the original putrid blood. This septic intoxication is of great importance in surgery, for in wounds to which micro-organisms are freely admitted these substances are produced, and if absorbed in moderate quantities give rise to fever, or, if in larger quantities, and rapidly, to death.

This condition of septic intoxication must be carefully distinguished from the action of other forms of micro-organisms which are parasitic on the animal body, and, growing in the blood or tissues, give rise to a large number of diseases grouped together under the term "Infective Diseases." Of these there are two groups, those in which the infection occurs from a wound or open surface—Traumatic Infective Diseases—and those in which no wound is necessary and where the pathogenic organisms are supposed to be able to enter the body through uninjured surfaces. Of these the traumatic infective diseases have been most completely worked out, and have been shown in a larger number of instances to be due to the action of specific micro-organisms. Some of these pathogenic organisms are not only parasitic on the living body but can also grow outside the body on dead organic substances, being ever ready, however, to become parasitic on a living body when an opportunity offers. One of the best examples of this is the bacillus of anthrax, which in the living body does not form spores. It can, however, grow on dead vegetables such as peas, especially when lime is present, and form spores, producing the disease again when taken into a living body. Other pathogenic organisms are, however, apparently incapable of growing outside the body though they retain their vitality for a considerable time in the dry state, and can grow when they again enter

a living body. One of the best examples of this is the bacillus of tubercle, which, though it can be artificially cultivated outside the body under special conditions, can seldom if ever meet with these necessary conditions in nature.

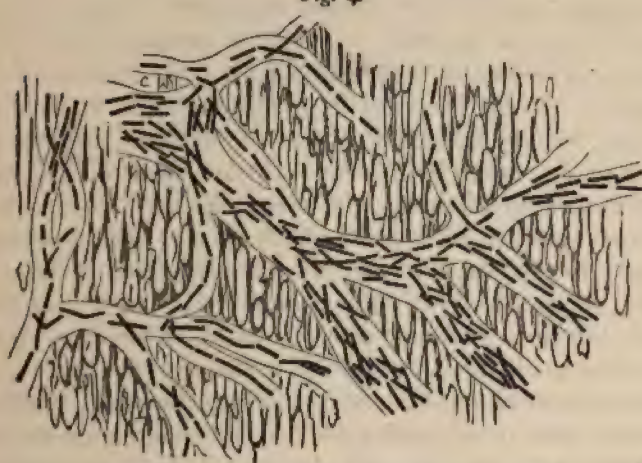
The following are the chief steps required for the proof that a given organism is the cause of a disease. Firstly, an organism of a definite form and with definite characteristics must always be found in the blood or in the affected parts of the animal body. The blood or the affected parts containing these organisms, when inoculated into another animal of the same species, must produce the same disease. Treatment of the blood or affected parts in such a manner as to destroy the micro-organisms present in them must also destroy their power of causing disease in another animal. When the diseased parts are inoculated on suitable soil outside the body the micro-organisms grow, and can be indefinitely propagated on similar soil.* When in this manner the organisms have been separated from the remains of the animal substances in which they were imbedded, their inoculation on a suitable animal must again produce the disease, the same organisms being also found in the diseased parts. This sort of proof has now been furnished for a considerable number of diseases.

The best known example of a disease due to micro-organisms in which the above proof has been furnished is that of anthrax or splenic apoplexy. This disease affects all mammalia, including man, and birds are also liable to be attacked by it. It may commence by the formation of a pustule of a carbuncular nature, but usually, especially when the disease is rapid in its course and the animal is particularly liable to it, no pustule is observed. Sometimes animals are suddenly struck down while apparently well, but generally the temperature becomes high, they stagger, bleed from the nose, mouth, &c., and rapidly die.

* The cultivation of some pathogenic organisms, for example of leprosy, and relapsing fever, has not yet been successful, but it is necessary for the absolute proof that they are the causes of these diseases.

In man the carbuncular form is not uncommon, and patients so affected may recover; when, however, the disease becomes generalised death almost always results. In the blood of animals affected with this disease one constantly finds rod-shaped organisms belonging to the class of bacilli. These bacilli are long and thick and are among the largest of the pathogenic bacteria. Not only are the bacilli present in enormous numbers in blood drawn from the body, but if after death portions of the organs are hardened in alcohol, cut into very thin sections, and stained with some of the aniline dyes, all the smallest blood-vessels

Fig. 4.



ANTHRAX BACILLI IN THE CAPILLARIES. × 700.

throughout the body will be seen to be full of these organisms (see fig. 4). The smallest quantity of blood containing these organisms rubbed into a scratch in another animal causes its death in a very short time, the same appearances being found. If this blood is exposed to a high temperature or treated with substances which destroy the vitality of these bacilli it no longer produces any effect when inoculated. If a previously heated wire is dipped into the infective blood and then introduced into a sterilised infusion, or stroked over a gelatinised nutritive material, or over a

purified potato, care being taken to prevent the entrance of extraneous organisms during and after the experiment, growth of the bacilli occurs in the fluid or on the surface of the solid substance, in the latter case forming the loose network mentioned before. From the first material a second may be inoculated, and then a third, and so on indefinitely till all trace of the original blood is lost except these bacilli. If now an animal be infected with the minutest quantity of these cultivated bacilli the same disease and fatal result follow as when the infective blood was employed. Heat or substances which kill the bacilli render the material harmless when inoculated. These facts show that the bacilli were the cause of the original disease, and as no other bacteria or anything else gives rise to this affection, the bacilli must be held to be the only cause.

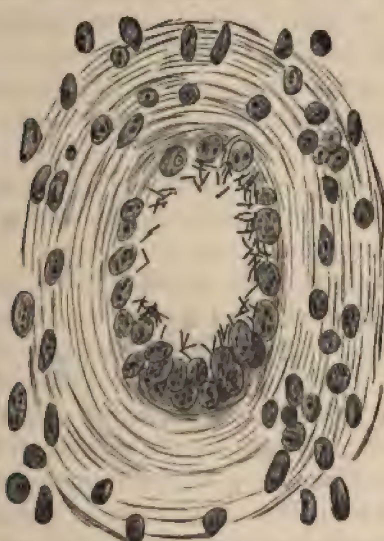
Glanders is a disease of horses in which ulcers and nodules are found in the mucous membrane of the nose and nodules in the lungs and other organs. This disease also affects man and other animals, and is almost always fatal. In the diseased parts minute bacilli are present in large numbers. They can be cultivated on gelatinised meat-infusion, potatoes and other materials, and their inoculation on animals gives rise to the same disease.

Erysipelas in man is a disease in which there is a spreading redness and inflammation of the skin, sometimes accompanied by the formation of abscesses. At the spreading margin large numbers of minute micrococci are found in the lymphatic vessels of the skin. These can be cultivated on potatoes, gelatinised meat-infusions, &c., forming whitish masses spreading over the cultivating material. The inoculation of these micrococci as also of erysipelatous pus on the ear of rabbits causes extensive redness, which generally passes off without producing any ill effects, and is followed by peeling of the skin in the same manner as occurs in man. Advanced cancerous and other diseases in man, in an unsuitable condition for operation have been benefited by an attack of erysipelas, and the use of these

cultivated micrococci has been as effectual in causing erysipelas and as beneficial to the patient as the use of erysipelatous pus.

Tubercular diseases assume a variety of forms in man of which the chief are phthisis and acute tuberculosis. In rodents we find only acute tuberculosis. In cattle and other animals there are various peculiarities, but the essential characters of the disease are the same. The inoculation of sputum from a case of phthisis, of portions of phthisical

Fig. 5.



GIANT CELL FROM A TUBERCLE CONTAINING TUBERCLE BACILLI. × 700.

lungs, of tubercle of cattle, &c., into rodents gives rise to acute tuberculosis. In the same way inhalation of tubercular material gives rise to acute tuberculosis in rodents. The inoculation of other materials, provided they are not tubercular, does not cause the disease. The disease, therefore, is infective and specific. Examination of tubercular materials, sputum, phthisical lungs, acute tuberculosis, &c., shows the constant presence of a peculiar form of bacillus

(see fig. 5), differing in certain chemical characteristics from most of the other known bacteria. The destruction of these bacilli removes the infective property of tubercular substances. The bacilli can be cultivated on solidified blood serum kept at the temperature of the animal body, and forms the peculiar S-shaped growths previously mentioned. These cultivated bacilli can be indefinitely propagated in successive generations in any number of tubes containing blood serum. The inoculation of these bacilli on animals causes acute tuberculosis, identical in every respect with the disease caused by inoculation of tubercular materials. They are,

Fig. 6.

MICROCOCCUS OF PNEUMONIA. × 800.

therefore, the cause of tubercular diseases, though it is probable that a variety of conditions, such as special predisposition, are necessary before they can grow in the living body.

In the affected parts of the lung in pneumonia in man are found micrococci which have the peculiarity of being surrounded by a capsule (see fig. 6). They may be single, in pairs, or chains. They are also present in the fluid in the pleural cavity and in the sputum. They may be cultivated

on potatoes or gelatinised meat-infusion, &c. If the point of a sterilised needle be dipped into the pleural fluid, or passed into the diseased lung, and afterwards pushed into gelatinised meat-infusion, a whitish growth appears along the track of the needle, and at the surface this growth assumes the appearance, in relation to that occurring along the track, of the head of a pin. These pin-shaped growths are peculiar to the micrococci obtained from some cases of pneumonia. These micrococci can be grown through an indefinite succession of generations. Their injection into mice is followed by pneumonia, and inhalation by mice of these cultivations also causes pneumonia in a considerable proportion of the animals.

Septicæmia in mice is a rapid disease, resulting in the death of the animal in one to two days, and has been shown to be due to the growth of a minute bacillus in the blood. These bacilli are found in large numbers in the blood and in the blood-vessels throughout the body. They can be cultivated in tubes, and the inoculation of the cultivated bacilli produces the disease. Inoculated on rabbits they only produce a local affection. A peculiarity of this disease is, that while it readily affects tame mice and house mice it does not attack field mice.

For rabbits and other animals a considerable number of pathogenic bacteria have been found, and complete proof has been furnished that the bacteria are the only cause of the disease. Among others may be mentioned various septicæmic diseases in rabbits and mice, chicken cholera, pneumoenteritis in pigs, &c.

Besides the bacteria one or two fungi have been found which are capable of living in the body and causing the death of the host. Among these are two species of mucor and *Aspergillus fumigatus*. In man there is also a fatal disease termed actinomycosis, which is evidently due to a fungus living in the tissues. In man there are various skin diseases, as ring-worm, favus, &c., also due to fungi growing in the cutaneous structures.

In other diseases in man the proof is not so complete as

in the diseases of which I have been speaking above, because animals have not yet been found which are liable to the disease. Fortunately, however, for the advance of medical knowledge, so many diseases of the same type have been shown to be due to bacteria as the result of experiments on animals, that in these cases the constant presence in the diseased parts of organisms, showing definite morphological characteristics and differences from other bacteria in their mode of growth on cultivating media, leads us by analogy to assume, practically with certainty, that they are the virus of the disease. In typhoid fever minute short thick bacilli are found in the ulcers in the wall of the intestine, in the mesenteric glands, and forming plugs in the vessels of the spleen and liver, and sometimes in the lungs. These bacilli can be cultivated, and their mode of growth presents special characteristics. In cholera a bacillus is present in large numbers in the walls of the intestine, somewhat resembling in appearance the bacillus of glanders, and capable of cultivation on suitable soil outside the body. In ague, during the shivering stage, bacilli of peculiar and distinctive appearance have been found in large numbers in the blood. In diphtheria a bacillus is often found at the part where the disease progresses; it can be cultivated, and the result of experiments on animals points very strongly to the view that it is the cause of diphtheria in man; but as yet no animal has been found in which the disease can be produced with all the characteristics of the affection in man.

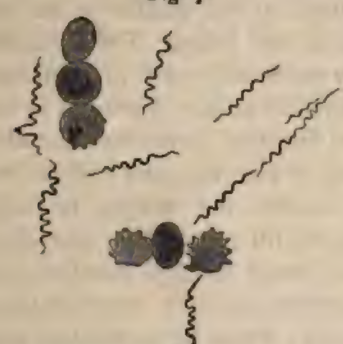
There are also some diseases in which definite organisms have been found in constant association with the morbid process, but these organisms have not yet been successfully cultivated. Thus in relapsing fever (see fig. 7), spirilla appear in the blood at the commencement and even before the commencement of the febrile attack, and increase rapidly in numbers till defervescence occurs. In leprosy enormous numbers of bacilli are found in the nodules, these bacilli being marked out from other forms

of bacteria as well by their appearance as by definite chemical characteristics.

These parasitic diseases are not confined to the higher animals, but they also affect those much lower in the scale of organisation. Thus the fungous disease of salmon and other fish is due to the growth of a fungus (*saprolegnia*) on the surface of the body; flies often die from the growth of a fungus (*Empusa muscæ*) in their bodies; and *pebrine* and *flacherie*, so destructive to the silkworm industry, are due to micrococci.

The demonstration of these bodies by means of the microscope is not always an easy matter, and when they

Fig. 7.



SPIRILLA FROM RELAPSING FEVER. × 700.

are present in tissues they can only be properly seen when they are stained. In the case of fluids one can by placing a drop under the microscope and using a sufficiently high power, generally see the bacteria and observe their movements, &c.; but when they are lying among other structures this is very difficult, and as a rule impossible. In the case of bacteria in fluids, also, it is always best to stain them. This is done by allowing the fluid to dry on the surface of a thin piece of glass (cover glass), and afterwards fixing the organisms to the glass by heating it, by passing it three or four times through a gas flame; the glass is then placed in the staining fluid for a sufficient length of

time, it is afterwards washed in water, dried and mounted in canada balsam. The materials used for this purpose are the basic aniline dyes, such as magenta, gentian violet, &c. In the case of tissues, fine sections are made, generally by means of a microtome, and stained in one of the above solutions. If now they are washed in dilute acetic acid, alcohol and oil of cloves successively, the colour disappears from the tissue, and only the bacteria and the nuclei of cells are left coloured. The processes employed are very various and not suitable for discussion in the present handbook. I may, however, mention one solution which is useful for almost all forms of bacteria. Take of a 1 to 10,000 solution of caustic potash in water—100 parts; add of a saturated alcoholic solution of methylene blue 30 parts, shake and filter; after staining in this for a few minutes the section may be washed, if very deeply stained, in dilute acetic acid ($\frac{1}{2}$ p. c.); if not very deeply stained, in water only.

There are two methods of cultivating bacteria, the one in which they are grown in a fluid and the other in which they are grown on some solid substance. The latter method is the one now generally employed as being the most free from error, though in some cases fluids are still useful. The most common danger in manipulating fluids is that bacteria may fall into them from the air, hands or instruments employed, and, growing by the side of those intentionally introduced, the two become mixed together, and the experiment is thus almost hopelessly ruined. If on the other hand a solid medium is employed, and bacteria accidentally gain access to the vessel during the manipulation, they grow at the point where they fell and do not necessarily mix with and spoil the organisms inoculated. Any impurity can thus be seen, and a fresh inoculation can be made before the organisms experimented with become contaminated by those which entered accidentally.

Fluid cultivating materials are usually infusions of animal or vegetable substances. These are in most cases neutralised, filtered, and introduced by a siphon into flasks

which have been purified by heating them at a temperature of 300° F. for two or three hours after their necks have been plugged by cotton wool. The fluid is then boiled two or three times at intervals of twenty-four hours, so that all the bacteria contained in it are destroyed, and the fluid remains pure so long as it is kept in the plugged flask. The best flasks for this purpose have a neck at the side, through which the fluid can be poured into smaller vessels. This neck is wide where it joins the bottle and narrow at the end. After fluid has been poured through it and the bottle is again placed upright a drop remains in the end so that no air enters the flask which has not been filtered through the cotton wool over the mouth of the flask. From this flask the fluid is poured into smaller flasks or tubes, which have in like manner been purified by heat, and are covered with caps of cotton wool after filling them. The fluid may be again sterilised by boiling, and then the flasks or tubes are kept for some days at the temperature of the human body. If the fluid still remains clear after a few days it may be looked upon as pure and used for experiments. The cotton wool cap being lifted momentarily, with precautions against the entrance of dust, the material to be tested, blood, pus, &c., is rapidly introduced, the cap again applied, and the flask placed in an incubator at 90° to 100° F. The material may be introduced by means of a syringe purified by heat, by platinum wire which has been heated, by sucking up a little in a capillary tube and dropping it in, &c. If growth occurs the fluid generally becomes turbid in a few days, the turbidity being due to the enormous numbers of bacteria present.

Solid-cultivating materials are boiled potatoes, coagulated blood serum, various infusions rendered solid by the addition of gelatine or agar-agar, &c. Potatoes are cleaned with a dilute solution of bichloride of mercury, steamed till they are cooked, divided with a heated knife, and placed on a dish under a glass cover with wet blotting paper around to keep them from drying up. Potatoes are very good soil for a large number of bacteria, and it is much

easier to carry on pure cultivations on them than in fluids. The disadvantage is that they are opaque, and that therefore the mode of growth of the organism experimented with cannot be observed under the microscope. This difficulty is obviated by the use of infusions, rendered solid by the addition of gelatine or agar-agar. The latter is in some cases an advantage, because it remains solid at the temperature of the body, at which gelatine is fluid. These gelatinised infusions are kept in pure tubes or flasks plugged with cotton wool, or they are melted and poured out on heated glass plates which are kept in a moist chamber and protected from the dust. The best composition for a cultivating material is an infusion of meat to which is added 3 per cent. pepton, $\frac{1}{2}$ per cent. common salt, and 5 to 10 per cent. gelatine, the whole being carefully neutralised. Most of the common forms of bacteria will grow on this, though modifications must be made in some instances. If this material is poured out on a glass plate and allowed to solidify, it may be inoculated with the bacteria under investigation, and their mode of growth observed. This is done by dipping the end of a fine platinum wire, which has been heated and allowed to cool, into the material containing the bacteria, and then rapidly drawing lines on the gelatine with it. Along various parts of the track of the needle bacteria remain, and if the pabulum is suitable and the temperature and other conditions correct, they grow in the form of colonies at these points. If any adventitious organism has fallen on the gelatine during the exposure it develops where it fell, and can easily be recognised as an impurity, while further cultivation may be made from the needle track before this adventitious colony has grown so large as to become mixed with those inoculated. At the same time, the gelatine being clear the growth may be observed under even comparatively high powers of the microscope, and may be photographed. As I have already stated, different organisms differ greatly in the form and mode of growth of the colonies which they form on a solid substratum, and in this way organisms, hardly

distinguishable under the microscope, may be readily separated from each other.

In other cases the pabulum employed is coagulated blood serum, and some organisms, such as the bacillus of tubercle, grow only sparingly and slowly on any other soil. The advantage of the serum is that it can be kept at the temperature of the human body without becoming fluid, and also that very few organisms liquify it while gelatine is liquified by almost all forms of bacilli.

The best cultivating material for microscopic fungi is a bread infusion, made by rubbing down bread, mixing it with water to a thick consistence, and sterilising it by heat.

I have already mentioned that when cultivations in fluids become impure, i.e. when other bacteria besides those intentionally introduced gain access to the fluid, and grow in it, the cultivation is lost, as it is a matter of great difficulty to separate the various forms from each other; at least, it was a matter of great difficulty till Koch introduced his method of cultivating on solid substrata. Before the solid method was employed the separation was made by what is termed the fractional method. Experiments were in this way successfully made by Sir Joseph Lister on the bacteria of the lactic fermentation of milk. He first estimated the number of bacteria of all kinds present in a given quantity of the fluid, for example in one drop. He then diluted this drop with boiled distilled water till every drop of the mixture thus obtained only contained one bacterium, supposing the organisms to be equally distributed throughout the liquid. To each of a large number of flasks containing sterilised milk or other cultivating material a drop of this diluted bacteric liquid was added. In a certain number of flasks nothing grew; but, in a certain number pure cultivations of the *Bacterium lactis* were obtained. This method, though very ingenious, is, however, very laborious and uncertain in its results, and is now given up in favour of the methods introduced by Dr. Koch. A sterilised, gelatinised infusion is liquefied, poured out on a sterilised plate of glass and

allowed to solidify. A fine platinum wire sterilised by heat is now dipped into the fluid containing the bacteria, and then drawn rapidly across the surface of the gelatine. In this way bacteria are sown along the track of the wire, and if a sufficiently small quantity be taken up on the point of a needle, and if the experiment be skilfully performed, it will be found that in parts of the track nothing grows, while at various points small colonies appear. It will be found on examination that some of these colonies consist of only one kind of bacteria, and pure cultivations can then be made from them. The following is another method. A minute quantity of the bacteric fluid is introduced into a tube containing the gelatinised material which has been liquefied at the body temperature. The fluid gelatine is now well shaken up so as to distribute the bacteria throughout the mass ; it is then allowed to solidify. In this way bacteria are caught at various points in the solid gelatine, and grow there to form colonies. On examination it will be found that many of these colonies are pure cultivations. It is more convenient, instead of retaining the gelatine in the tube, to pour it on a sterilised glass plate while it is still fluid, as in this way there is readier access to the colonies after their development for examination and further cultivation. These glass plates are kept in vessels to protect them from the dust, moistened blotting paper being present to prevent drying of the gelatine.

It is on this last principle that Koch's method of examining water is based. A measured quantity of the water to be examined is well mixed with a measured quantity of liquefied sterilised gelatine material, and this is poured out on a sterilised glass plate, and kept moist and protected from dust as in the previous instance. At various points in the gelatine organisms develop and their number can be counted, while, as previously mentioned, the class to which they belong may be determined by their method of growth even without having recourse to the microscope. In case of difficulty, any particular colony can be examined under the microscope, and if necessary inoculated into a

suitable animal. This method of examination has been carried out for a long time under Dr. Koch's direction in the Sanitary Institute at Berlin, and in the report of any specimen of water sent to him for examination, not only is the chemical analysis given, but also the number and kind of micro-organisms present are mentioned.

Soil is examined in the same manner. The soil to be investigated is crushed with precautions against the entrance of organisms other than those originally present and in the soil. It is then scattered over the surface of gelatine, spread on plates, as in the foregoing method, and the number and kind of the organisms which develop is in this way determined. Already valuable results have been obtained in this way. For instance, in a hospital at Amberg, an epidemic of pneumonia broke out, and a large number of patients died. Dr. Emmerich examined the soil under the floor of the ward, and found there large numbers of the peculiar micrococci, which seem to be the cause of that disease; these are not present in the same situation in healthy wards. He was in this way enabled to determine the cause of the outbreak.

By the use of the gelatine method air can also be very conveniently and accurately examined. Plates covered with a layer of sterilised gelatine may be exposed in various situations for various lengths of time, and the number and character of the organisms which fall on them may be readily determined (see fig. 8). Air may also be analysed quantitatively by the same method. Into long tubes, the walls of which, more especially the lower wall, are covered with a layer of sterilised gelatine, a known quantity of air may be aspirated and the dust allowed to settle. Development occurs at various points, and the number and kind of the organisms present in a given quantity of air may be determined. Very interesting results obtained by this method are given by Dr. Hesse in the second volume of the "Mittheilungen des Gesundheitsamtes in Berlin," and the accompanying woodcut is copied from one of his plates. Another method is employed by Dr. Miquel of the

Mont Souris observatory in Paris. He introduces a definite quantity of the air from certain localities into a large number of flasks containing sterilised infusions, and counts the number of flasks in which development occurs and the kind of organism in each flask. This method is, however, not so exact as the other, and there are many objections to it; for example: in Hesse's experiments it was found that the organisms in his tubes develop at different dates. Now, if two organisms of different rapidity of growth gain access to the same flask of meat-infusion, the one which grows first may entirely prevent the development of the second, while in many cases two organisms may

Fig. 8.

RESULT OF EXPOSURE OF A LAYER OF GELATINISED MEAT-INFUSION TO AIR. DEVELOPMENT OF VARIOUS FUNGI AND BACTERIA AT DIFFERENT PLACES ON THE GELATINE. (NATURAL SIZE.)

resemble each other very closely in microscopical appearance but differ in the appearance of their growth on a solid substratum.

One of the most important functions of these laboratories is to determine the best means of destroying the bacteria associated with disease, i.e. to determine the best methods of disinfection. Only in some of the infective diseases has the cause been as yet made out, and the bacteria already proved to be the cause of disease differ much in their resistance to various disinfecting means. The most resistant of all are, however, the spores of some bacilli, more especially of bacillus anthracis, and of a short thick bacillus

found in earth. If, therefore, substances and methods are tested as to their power of destroying these most resistant bodies, it is practically certain that they will be efficient as disinfecting means in all cases. This matter has been worked out very carefully by Dr. Koch, by the aid of his new method of cultivation. It is not merely of importance to determine what will destroy these bodies, but also what will impede or prevent their growth ; and it has been found that it is much easier to hinder the growth of bacteria than to destroy them. The method adopted by Koch was to soak sterilised threads in spore-bearing cultivations of anthrax bacilli and also in cultivations of non-spore-bearing and less resistant forms, such as micrococcus prodigiosus, and also to use dried earth, which always contains the thick bacillus with the very resistant spores. Among chemical substances able to destroy these spores with great rapidity he found that bichloride of mercury was the most potent. Mixed with the cultivating material in the proportion of 1 to 300,000, the bacillus anthracis was unable to grow. Spores of anthrax dried on threads and placed in a solution of 1—20,000 for ten minutes were incapable of development, but a weaker solution than this was uncertain. Solutions of 1 to 5,000, or stronger, destroy all spores with certainty in a few minutes ; indeed, it was found that to wet the spores with a spray of this solution and then allow them to dry sufficed for their destruction. A large number of other substances acted in the same manner, though not in such dilute solutions.

Of the various other disinfectants employed, only the following were able to *kill* the spores of the anthrax bacillus in less than 24 hours.

Chlorine water.
Bromine (1 per cent. in water).
Iodine water.
Permanganate of potash (5 per cent. in water).
Osmic-acid (5 per cent. in water).

The following acted slowly or imperfectly on the vitality of the spores.

Ether (incomplete destruction after eight days, complete destruction of life after thirty).

Aceton (incomplete after five days).

Iodine, 1 per cent. in alcohol (incomplete after one day).

Sulphuric acid, 1 per cent. in water (incomplete after ten days).

Sulphate of copper, 5 per cent. in water (incomplete after five days).

Boracic acid, saturated watery solution (incomplete after six days).

Hydrochloric acid, 2 per cent. in water (complete on the tenth day).

Arsenious acid, 1 per thousand in water (complete after ten days).

Sulphurous acid (incomplete after five days).

Sulphide of ammonium (complete after five days).

Formic acid 1·12 s. g. (complete on the fourth day).

Quinine, 2 per cent. in water ($\frac{2}{5}$) and alcohol ($\frac{3}{5}$) (incomplete after one day).

Quinine, 1 per cent. in water with hydrochloric acid (complete on the tenth day).

Turpentine oil (incomplete on the first day, complete after five days).

Chloride of lime, 5 per cent. in water (incomplete on the first and second day, complete after five days).

Chloride of iron, 5 per cent. in water (incomplete on the second day, complete after six days.

Carbolic acid in 5 per cent. watery solution killed all the spores between the first and second day. In 5 per cent. oily or alcoholic solution it produced no effect on spores, and bacilli without spores which are killed by the watery solution in a few seconds were not destroyed by the oily and alcoholic solutions till the sixth day. The question has been raised whether the evaporation of carbolic acid at the ordinary temperature would be sufficient to disinfect the air, but this must be answered in the negative. Spores of the earth bacillus placed in a vessel with carbolic acid and exposed to the vapour of carbolic acid for 45 days, developed as readily as before the experiment was commenced. On the other hand, if the vapour of carbolic acid is heated, although precautions are taken that no more is given off than at the ordinary temperature, the action becomes very rapid, so that carbolic acid vapour at a temperature of 167° F. almost completely destroys the spores of the earth bacillus in two hours, though this temperature of itself does not in the least impair the vitality of the spores.

Sulphurous acid is another disinfectant which is much used, but which turns out to be overrated. Dry micrococci are killed by a 1 per cent. vapour per volume in 20 minutes ; if moist, in two minutes. Therefore, for a disease due to micrococci it is sufficient, but it is quite different when it is tested on spores. Spores of anthrax, earth and hay bacilli, exposed for 96 hours to a vapour of sulphurous acid, at first of the strength of 6·13 vol. per cent. and after 96 hours of the strength of 3·3 per cent., were quite unaffected.

Such are examples of the results obtained by this method, and they show that though the ordinary disinfectants in use are sufficient when the virus is a bacterium which is not spore-bearing, yet where spores have to be dealt with they are insufficient. In the case of those diseases in which the cause has not yet been worked out, it is safest to treat them as if the virus possessed the resisting power of the most resistant spores, though it may turn out later that it does not do so.

In disinfecting fluids other factors come into play. Thus, one disinfectant may form compounds with substances in the fluids and lose its properties, while another which is in reality weaker may not do so, and thus be more effectual. Thus, in recent experiments on the destruction of the tubercle bacillus in phthisical sputum, Schill and Fischer found that corrosive sublimate solution (1—500 in water) added to an equal quantity of sputum failed to destroy the tubercle bacillus even after 24 hours' action, while carbolic acid (5 per cent.) added in the same proportions to sputum disinfected it thoroughly in 24 hours. And yet, acting on dry spores of bacillus anthracis the sublimate solution is much more effectual than the carbolic acid. In the case of sputum the difference probably depends on the different chemical affinities of the two substances, the sublimate either losing its antiseptic properties by entering into new combinations, or being unable to penetrate and act on the masses of secretion which contain the bacilli.

Among other methods of disinfection, the most popular are disinfection with hot air and with steam. Dr. Koch's results show that disinfection of clothing, bedding, and large

masses of material is impossible with hot air. One experiment will show where the fallacy lies. It is known that spores can resist dry high temperatures for a long time, but that two or three hours' exposure to a temperature of about 300° F. will effectually destroy them. At this temperature clothes are destroyed ; they become brown and useless. But, independently of this fact, Koch made the interesting discovery, that when a roll of clothes is put into a baking apparatus, though the clothes may become brown at the outside, the temperature in the interior of the mass is very low, and quite useless for disinfecting purposes. Thus, a piece of linen, about 40 inches long, was rolled up tightly, and 32 complete turns were in this way made, giving 64 layers from one side to the other. A maximum thermometer was placed in the middle of the roll, and between every fourth turn from within outwards. Beside each thermometer were placed spores of bacillus anthracis, of earth bacillus, and micrococcus prodigiosus, a non-spore-bearing organism very readily killed. The whole was placed in the disinfecting oven. The experiment began at 2 o'clock p.m., and lasted for four hours. The temperature of the air in the interior of the oven was taken at different times and was as follows :

At 2	p.m.	227° F.
„ 2.20	„	284° F.
„ 3	„	293° F.
„ 4	„	298° F.
„ 4.30	„	298° F.
„ 5	„	302° F.
„ 5.30	„	298° F.
„ 6	„	298° F.

When taken out at 6 p.m., the following were the readings of the maximum thermometers :

In the middle of the roll			94° F.
4 turns from the middle			109° F.
8	„	„	126° F.
12	„	„	152° F.
16	„	„	165° F.
20	„	„	175° F.
28	„	„	212° F.

If the roll was moist the result was still less favourable. A similar roll, which had been moistened, was placed in the oven at the same time, and the thermometers in it stood as follows:

In the middle	114·5° F.
4 turns from the middle	129° F.
8 " "	131° F.
12 " "	142° F.
16 " "	152·5° F.
20 " "	159° F.
24 " "	165° F.
28 " "	166° F.

Of the organisms enclosed, micrococcus prodigiosus within the central 18 turns (it was not placed further out) was unaffected, and the bacillus spores which were placed outside the 24th turn also grew. Spores of these bacilli lying free in the oven were destroyed. It is thus evident that dry heat is useless as a method of disinfecting bedding and masses of clothing.

It was also found that there was the same difficulty with steam, even though it were much superheated. The temperature in the central parts of large masses of cloth was very much below that of the steam outside, and much too low to be effectual as a disinfecting agent. If, however, the steam, instead of being shut up in a closed vessel, was allowed to flow through the vessel, there being thus a constant current of steam, at 212° F., the result was very different. In a comparatively short time even large masses were thoroughly heated throughout, and the steam at this temperature acted like boiling water, and completely destroyed the spores in the interior of the masses. Further, the steam injured the various woollen and other fabrics much less than the hot air, and it is evident that where heat is to be employed as a disinfecting agent, it must be employed in the form of a current of steam at 212° F. constantly passing over the material for about three hours.

In connection with this subject it must also be mentioned, that recent experiments have shown that it is possible to

diminish the virulence of certain of these pathogenic micro-organisms, and when this is done it is found that in some cases the inoculation of the attenuated virus protects the animal against the effects of the virulent form. Pasteur found, with regard to the organism of fowl cholera, that if it is cultivated in a thin layer of fluid for some months it loses its virulence, and may be inoculated into fowls without causing death, these fowls being now protected against attacks from the virulent organism. Toussaint found that by heating blood containing bacillus anthracis to 134·6° F., and adding carbolic acid, the organism diminished in virulence, and its inoculation protected animals more or less from the virulent form. Chauveau found that by heating for 15 minutes at 125·6° F., or for 20 minutes at 122° F., a sufficient attenuation was obtained. Pasteur cultivated these bacilli at 107·6° F., and thus gradually diminished the virulence of the organism. Koch has worked out the degrees of attenuation which are most suitable for the purpose of affording protection. It has also been found by Pasteur that a virus may be attenuated not only by cultivation in flasks, but by inoculating animals belonging to different species. In certain cases, the blood of these animals, when inoculated into animals of the species in which the disease naturally occurs, causes a mild form of the disease and protects the animal from the more virulent attack.

From this short sketch the great importance of the work done in a laboratory of this kind will be evident, and it is remarkable that in this country there is no public laboratory devoted to these researches. The functions of the bacteriological laboratory in connection with hygiene may be summarised as follows :

1. The investigation of the causes of infective diseases in man and animals, the cultivation of the micro-organisms causing them where they are due to micro-organisms, and the study of the life history of these organisms. In connection with this part of the subject we have the various methods of staining and cultivating organisms, and also of

photographing them. It is also of importance that other organisms, not specially connected with disease but nevertheless of great importance in nature, such as those associated with fermentations and food, should be studied. In this connection also the parasitic diseases of plants deserve special notice.

2. The investigation of air, water and soil, for the presence of micro-organisms, also the determination of the kinds found, and their relations to disease.

3. The discovery of the different methods of destroying these organisms, or of making them useful instead of hurtful. Here we have to do with experiments on disinfectants, and also with the valuable experiments on the attenuation of virus, and the conversion of hurtful organisms into useful vaccine materials.

CATALOGUE OF EXHIBITS

IN THE

BIOLOGICAL LABORATORY.

Microscopes and microscopical apparatus exhibited by Messrs. C. Baker, 244 High Holborn, W.C.

R. & J. Beck, 68 Cornhill, E.C.

C. Coppock, 100 New Bond Street, W.

Powell and Lealand, 170 Euston Road.

J. Swift & Son, 81 Tottenham Court Road.

Carl Zeiss, Jena.

All these makers kindly allow their instruments to be shown in use.

Staining materials exhibited by Messrs. R. & J. Beck and Dr. G. Grübler, 17 Dufour Strasse, Leipzig.

Microtomes by Messrs. Swift & Son, R. & J. Beck, and A. Frazer, 7 Lothian Road, Edinburgh.

Apparatus for bacteriological research, by Dr. Hermann Rohrbeck, 100 Friedrich Strasse.

Diagrams of parasitic diseases of plants, by Worthington Smith, Esq.

Most of the bacteria, as well as the maps of infective diseases and the vaccination statistics have been obtained from Dr. Koch's laboratory in Berlin.

The glass apparatus used in the laboratory is supplied by Mr. E. Cetti, 36 Brooke Street, Holborn, E.C.

The staining reagents used in the laboratory are supplied by Dr. Georg Grübler, 17 Dufour Strasse, Leipzig. Agent in England, Mr. C. Baker, High Holborn, W.C.

Demonstrations are given every Thursday at 4 P.M.

1. *Apparatus used in the Cultivation of Bacteria.*

Flasks of various kinds, test tubes, glass slides, glass dishes, platinum needles, glass cells, microscopic slides.

Two forms of hot stage, exhibited by T. P. Hawksley, Oxford Street.

The flasks and test-tubes are plugged with cotton-wool, placed in a hot air chamber at the temperature of 300° Fah. for three hours. In this way all micro-organisms in their interior and in the cotton-wool are destroyed and a sterilised cultivating material may be kept in them without risk of contamination.

Glass slides, &c., are placed in a beaker plugged with cotton wool and subjected to the above temperature for three hours.

Dishes, &c., may be disinfected by washing in a 1 per 1000 watery solution of bichloride of mercury. This may then be got rid of if necessary by rinsing in boiled water or washing with alcohol.

Platinum needles are simply heated to redness in the gas flame.

2. *Cultivating Materials.*

(*a*) Boiled potatoes. Old potatoes are thoroughly washed with water and then with the bichloride of mercury solution (1 per 1000), and steamed for half-an-hour. They are cut with a large previously-heated knife (the hand in which they are held being previously dipped in the bichloride of mercury solution), and placed in a glass dish with cover purified as above described. A piece of moist filter paper is placed in the glass dish to prevent drying of the potato.

(*b*) Meat infusion. One pound of meat is chopped up and infused with 37 ounces of water for two or three hours, or is placed in the water in an ice safe for 24 hours. In the latter case the meat is pressed after 24 hours to get rid of all the fluid. The fluid obtained in either of these ways is then boiled and filtered. If desirable it may be neutralized, or peptone or other ingredients may be added to it before filtration. The clear fluid is then introduced by siphon into a sterilised flask, steamed for fifteen to twenty minutes on two or three successive days, and set aside for use.

(*c*) Gelatinised meat infusion.

Constituents :—

Lean meat, 1 lb.

Gelatine (5 to 10 p. c.) 1½ to 3 ounces.

Peptone (1 to 3 p. c.) 2½ to 7½ drachms.

Common salt (·1 p. c.) 15 grains.

Water about 37 ounces.

(Instead of gelatine, Japanese isinglass (1 to 2 p. c.) may be used).

A meat infusion is obtained as described in (*b*), only half the quantity of water, however (16½ ounces), being used.

The gelatine is soaked in the other half of the water until it is thoroughly saturated; it is then added, with the water which is not absorbed, to the extract of meat. The whole is now boiled for some minutes to complete the solution. The peptone and salt are then added and dissolved. The mixture, which is acid, is neutralised by the addition of carbonate of soda or neutral phosphate of potash.

The solution, now very turbid, may be rendered clearer by beating up with it the whites and shells of two or three eggs and then boiling briskly. The egg albumen, coagulated by the heat, rises to the surface and carries with it the solid particles.

A perfectly limpid solution is now obtained by filtering the fluid in a water-bath.

The material is then introduced into the sterilised test-tubes or flasks, and steamed on three successive days for a quarter to half-an-hour on each occasion. When it cools we have a perfectly clear cultivating material, solid and remaining solid below 80° F.

(*d*) Milk. The milk (skimmed milk is best) is introduced by siphon into sterilised flasks and steamed for fifteen to thirty minutes on three successive days.

(*e*) Bread. One part of bread and two parts of water introduced into a sterilised flask and steamed for fifteen to thirty minutes on three successive days.

(*f*) Solidified blood serum.

Serum free from blood corpuscles is collected, introduced into sterilised tubes, and kept in a water-bath at 58° C. (136·4 F.) for an hour on six successive days. The tubes are then laid obliquely in a water-bath, and the temperature kept at 65° C. (149° F.) till they solidify.

The necessary apparatus is exhibited.

3. *Cultivations of Micro-organisms.*

These are growing in the various materials mentioned above. The potatoes are inoculated by dipping the heated platinum needle into a pure cultivation of the micro-organisms and stroking it over the potato. The tubes are inoculated by dipping the

heated needle into a pure cultivation and pushing it into the fresh gelatinised material, the tube being held obliquely to prevent dust falling in. The serum is inoculated by rubbing the needle carrying the bacteria over the surface.

In looking at the cultivations in gelatine, observe the production of colour, liquefaction of the gelatine, the mode of growth along the needle track and the growth on the surface.

(*a*) Pigment producing organisms. None of these are hurtful to animals.

Torula producing a black colour, cells oval, black colour only formed in contact with air, forms black colour on potato; obtained from air.

Torula producing pink colour, cells almost round, red colour only formed in contact with air, grows on potatoes; obtained from air.

Micrococcus Indicus.—A large micrococcus, producing scarlet colour, grows on potatoes and the gelatinised material, liquefies the gelatine. Obtained by Dr. Koch in Egypt from the air.

Micrococcus Prodigiosus.—A large micrococcus producing blood red colour, size $\frac{1}{2}$ to 1 μ in diameter. Grows on potatoes, bread, the gelatinised material, &c., liquefies the gelatine. Very common in the air in certain localities.

Bacillus producing a violet colour, liquefies gelatine, violet colour formed in contact with air; obtained from water.

Bacillus causing fluorescence of the material in which it grows, does not liquefy gelatine.

Bacillus of green pus produces green colour and liquefies gelatine, also causes fluorescence. Obtained from wounds, and there causes the green colour sometimes seen in the discharges.

Bacillus of blue pus produces blue colour in contact with air, and liquefies the gelatine. Obtained from wounds, where it makes the discharge of a blue colour.

Sarcina producing yellow colour, growing in the gelatinised meat infusion.

Closely allied to the above, but not producing colour are

Sarcina Ventriculi found in the vomit in many cases of cancer of the stomach. Grows in whitish colonies.

(*b*) Organisms which are found in milk.

Torula cerevisiæ, the cause of the alcoholic fermentation.

Bacillus of blue milk.—A bacillus (size 2·5 to 3·5 μ in length) which is occasionally found in milk and produces a blue colour. The bacillus grows on potatoes and causes a dark blue colour

In gelatine the colour is greenish blue and the gelatine remains solid, the growth spreads out from the needle track forming a tree-like growth.

Milk inoculated with the above bacillus showing blue colour.

Bacterium lactis.—A minute bacillus (1·5 to 3 μ in length), the cause of the lactic fermentation of milk. In the gelatinised medium forms a delicate whitish growth along the needle track, grows slightly on the surface.

Milk sterilised and inoculated with the bacterium lactis showing the pure lactic fermentation.

Bacillus of butyric fermentation.—Size, 3 to 10 μ in length, below 1 μ in breadth. Grows in the gelatinised material, liquefies it and forms a scum on the surface. Produces the butyric fermentation.

Milk sterilised and inoculated with the butyric bacillus showing the pure butyric fermentation.

Micrococcus frequently found in milk. Grows in gelatine in form of delicate colonies, the gelatine remains solid. Produces no apparent change in milk.

Milk inoculated with the above micrococcus apparently unchanged.

Oidium lactis, a fungus found often in milk. Growing in bread infusion.

Milk inoculated with oidium lactis apparently unchanged.

(*c*) Organisms associated with diseases in man.

Bacillus of tubercle.—Found in all tubercular affections in man and animals; it may be cultivated on the coagulated blood serum at the temperature of the human body; it grows slowly and forms whitish irregular crusts on the surface. The specimen shown is the 21st cultivation from the lung of a patient who had died of phthisis

Bacillus of glanders.—Found in all cases of glanders; may be cultivated on blood serum or potatoes kept at the temperature of the body; on blood serum forms small round moist semi-transparent colonies. It grows very slowly on the gelatinised material at the ordinary temperature, forming a whitish mass.

Micrococcus of acute osteomyelitis.—Always found in pus from acute osteomyelitis; forms orange yellow colonies on potatoes, liquefies gelatine, and forms orange yellow deposit; produces acute osteomyelitis in rabbits when injected into the veins if bones have previously sustained any injury.

Bacillus of enteric fever.—Always found in typhoid ulcers,

mesenteric glands, frequently in spleen and liver as plugs in blood-vessels, grows slowly in the gelatinised material, forming somewhat brownish almost homogeneous growth along the track of the needle. Grows slightly on surface.

Micrococcus of pneumonia.—Found in most cases of acute lobar pneumonia, grows rapidly in the gelatinised material, forming whitish growth along the track of the needle, and a rounded mass on the surface, the whole resembling a nail.

Micrococcus of erysipelas.—Present in all cases of erysipelas in man in lymphatic vessels at spreading margin of redness; may be cultivated on gelatinised meat infusion, potatoes or blood serum; grows slowly in gelatine, forming delicate colonies along the track of the needle.

Bacillus Anthracis.—Size, 5 to 20 μ in length; 1 to 1·25 m. in breadth; may be cultivated on a variety of substances, grows in the gelatine in the form of a loose network, and soon liquefies it.

Attenuated bacilli of Anthrax.—By growing these bacilli between 42° and 43° C. (107·6° to 109·4° F.) they gradually lose their virulence, till by and by they will not kill any animal. When partially attenuated they may act like vaccine in not only not killing the animal into which they are inoculated but in protecting it from the virulent disease. The specimen exhibited will not kill any animal.

Also microscopical specimens of the bacillus of leprosy, the spirilla of relapsing fever and the *cholera* bacillus.

(*d*) Organisms fatal to lower animals but not affecting man.

Bacillus of mouse septicæmia.—Very small, ·8 to 1 μ in length; frequently present in decomposing fluids, grows in the gelatinised material, forming a delicate haziness around the needle track.

Bacterium of rabbit septicæmia.—A small oval organism (1·4 μ in length, ·7 μ in breadth) growing in the gelatinised material as a delicate brownish growth along the needle track. Probably the same as Davaine's septicæmia; very fatal to rabbits when inoculated, death occurring within 24 hours.

Fowl Cholera.—Small bacteria closely resembling in appearance and mode of growth the rabbit scepticæmia, kills fowls in 17 to 20 hours.

Micrococcus tetragenus.—A micrococcus with the cocci arranged in groups of 4; frequently found in phthisical sputum; when unstained it closely resembles sarcina; grows in the gelatinised material, forming large flattened milk-white colonies along the

needle track, and on the surface gives rise to an irregular plate. When inoculated into guinea pigs and mice, the animals die in 2 to 10 days, the organisms being present in large numbers in the blood.

Also microscopical specimens of the bacillus of malignant œdema in guinea pigs (*vibrion septique*, *Pasteur*), and the bacillus of foul brood in bees.

(*e*) Fungi.

Tinea or Favus Galli.—Forms crusts on the comb and wattle of fowls which may spread over the breast and back, belongs apparently to the class of torula; grows on the gelatinised material as a thin whitish growth; pure cultivations mixed with vaseline or glycerine, and rubbed on the combs of healthy fowls produce the disease.

Aspergillus flavescens.

Aspergillus fumigatus.—Growing on bread infusion. Both these organisms, when injected in sufficient quantity into the veins of rabbits, cause the death of the animals by growing in the capillary blood-vessels.

Aspergillus niger.

Aspergillus albus.—Also growing on bread infusion. Neither of these can live in the animal body.

Mucor, described by Lichtheim, kills rabbits when injected into the veins.

Mucor not pathogenic.

4. *Staining Materials and Methods.*

Bacteria are most satisfactorily examined after being stained. In the case of fluids a drop is placed between two cover-glasses, the glasses are squeezed together so as to get a thin layer, and then they are slipped apart and set up to dry. When dry they are heated to make the layer adhere to the glass, either by passing the cover-glass thrice through the gas flame, or by keeping them at from 100° to 120° C. for an hour.

Ehrlich's method is to place a lamp under one end of a brass plate and to allow the plate to stand till it has got thoroughly warm; then ascertain the part of the plate where water boils, place a cover-glass at that place, and one a little nearer to the flame and leave them an hour. They are then stained by floating them on the surface of the methylene blue solution mentioned in the text or in a methyl violet or other solution.

The methyl violet or fuchsin solution is made by adding a saturated alcoholic solution to distilled water till a sufficiently deep colour is obtained. The cover-glasses are floated on these solutions for about ten minutes, then washed in water and afterwards in a ½ to 1 p. c. solution of acetic acid, dried and mounted in Canada balsam. They may also be stained brown for photography in a saturated watery solution of vesuvin.

For tubercle bacilli a different solution is employed. Add to 100 parts of a saturated watery solution of aniline, 11 parts of a saturated alcoholic solution of fuchsin, filter and use as above. At the ordinary temperature the material must stain for 12 to 24 hours, at the body temperature for 2 to 3 hours, at a temperature near the boiling point for a few minutes. Afterwards immerse for a few seconds in diluted nitric acid (1 part of strong nitric acid to 2 parts of water). Wash in water and stain in a solution of methylene blue (100 parts of water, 20 parts of saturated alcoholic solution of methylene blue) for about an hour, wash in water, dry, and mount in Canada balsam. The tubercle bacilli remain red, all other bacteria (except leprosy bacilli) and the nuclei of the cells become blue.

For bacteria in tissues harden in alcohol for two or three weeks, then take a small piece, place in water for two or three hours, then in a strong solution of gum, freeze and make sections with microtome. Stain in the alkaline methylene blue solution or in solutions of the other stains, wash in water, dilute acetic acid, alcohol, oil of cloves or cedar, and mount in Canada balsam. For tubercle bacilli use the stain mentioned above, afterwards wash in water, alcohol, oil of bergamot or cloves, and mount in Canada balsam.

Gram's method of staining bacteria is very simple and beautiful. Take 100 parts of saturated watery solution of aniline, add 11 parts of saturated alcoholic solution of gentian violet. After cutting the sections place them in absolute alcohol, then in the above solution for two or three minutes (tubercle for some hours), then immerse in solution of iodine and iodide of potassium (1 part of iodine, 2 parts of iodide of potassium, 300 parts of water) till they are decolorized (a few minutes as a rule), then place in absolute alcohol, for a second or two in a saturated watery solution of vesuvin or Bismark brown, again in absolute alcohol, oil of cloves, and mount in Canada balsam. The bacteria appear dark blue, the tissue brown. Successful staining is only a matter of experience.

5. *Demonstration of Bacteria.*

For this good microscopes with condensers are required. More important even than powerful lenses is correct illumination of the specimen.

Various bacteria are shown under the microscope on Thursday afternoons.

A *microphotographic apparatus* is also exhibited.

Also a number of *microphotographs* taken by Dr. Koch of erysipelas, anthrax, relapsing fever, mouse septicæmia, rabbit septicæmia, pyæmia in rabbits, ulcerative endocarditis, acute osteomyelitis, &c.

6. *Examination of Air, Water and Soil for Bacteria.*

Various experiments are shown. The methods are referred to in the text.

The glass plates for the water cultivations are sterilised in an iron box shown. They are laid in glass dishes prepared as above described for potatoes, and the apparatus placed on a level plate of glass on a levelling stand. The plates of glass may be marked out in squares to facilitate the numeration of the bacteria. The cultivation is left for three or four days to develop and is then taken out, placed on a black ground, and the number of colonies of bacteria counted and their kinds ascertained under a low power of the microscope.

The tubes used in Hesse's air experiments are sterilised in the steaming apparatus after being filled with the gelatinised material Apparatus for growing bacteria in various gases is also shown.

Also Pasteur's experiment to disprove spontaneous generation.

7. *Method of testing the Power of Disinfecting Agents in destroying Bacteria.*

Apparatus and experiments are shown.

The power of killing (1) spores and (2) mature actively growing organisms must be tested.

The organisms generally used are spores of anthrax bacilli, and for non-spore-bearing organisms, micrococcus prodigiosus.

Sterilised cotton threads are soaked in the cultivations of the organism to be tested, and are then rapidly dried in a desiccating chamber. When spores are used the threads may be kept for

weeks or months in a dry state, without the vitality of the spores being impaired. In the case of non-spore-bearing organisms, the threads must be used within two or three days after drying. The prepared threads are placed for varying periods of time in the solution to be tested or subjected to the temperature, &c. They are then removed, and in the case of immersion in chemical solutions, washed in boiled distilled water, to get rid of the antiseptic, and planted on the solid gelatinised material spread out on a glass plate and kept protected from dust. The occurrence of growth is then observed. In the case of the pigment-producing organisms, the production of the proper colour shows that the organisms have not been killed. In the case of anthrax, the method of growth is typical and easily recognised. If there is any doubt a mouse may be inoculated with the cultivation.

8. *Parasitic Diseases of Plants.*

A large number of *diagrams* are exhibited by Worthington Smith, Esq., illustrating diseases of potatoes, clover, turnips, corn, &c.

C. B. Plowright, Esq., exhibits various dried specimens of ergot, canker of apple-trees, diseases of corn, &c.

Also two plants showing the effect of parasitic fungi.

1. A plant of barberry which last year had no æcidium upon it, was on the 22nd of May last infected with germinating spores of Puccinia graminis on wheat straw. On May 30th spermogonia first began to indicate their appearance by the production of yellow spots. Three days later they became well developed, and have now (July) been succeeded by the æcidium berberidis. The straw with the Puccinia upon it used in this culture is tied up in a little bundle and placed in the same pot.

2. A well grown plant of poa trivialis infected on the 9th of May with æcidiospores from ocidium on ranunculus repens. On May 20th the infected leaves began to show sickly yellow spots. On May 22nd the perfect uredospores were developed. On June 3rd abundant development of the uredo with some teleutospores of uromyces poæ beginning to develop.

9. *Maps showing the Death-rate of Children in Germany.*

Tables showing the relative prevalence of infective diseases in various towns. These are not a complete series, but have been

lent by Dr. Struck, of the Kaiserlich Gesundheits Amt in Berlin, to show the method of registration employed.

Dr. Struck also lends tables showing the effect of the introduction of compulsory vaccination in Germany on smallpox. There was no compulsory vaccination in Germany except in the army till 1874. The German law now compels vaccination in childhood and revaccination at 12 years of age. A third vaccination is compulsory in the army.

Part II.—HYGIENIC LABORATORY.

BY

W. H. CORFIELD, M.A., M.D., F.R.C.P.,

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PUBLIC HEALTH

LABORATORY WORK.

II.

THE work of a hygienic laboratory chiefly consists in the chemical and microscopical examination, and in the general study, of all those natural and artificial substances which, on account of the uses made of them, have some bearing on the Public Health.

Such work therefore includes the examination of drinking waters, of air and of soils ; of foods and drinks of every description ; of the various substances used in the construction and decoration of houses, such as wall-papers and paints ; and of the materials used for clothing, especially as regards the dyes which are applied to them. The comparison and valuation for sanitary purposes of filtering materials and disinfectants, and the examination of drugs and patent medicines also form part of the ordinary work of a model hygienic laboratory.

New methods of chemical analysis are constantly being devised, and the value of these has necessarily to be ascertained, and while there is a wide field for original work in the invention of new processes, the hygienist has also great opportunities for research in the study of the causes of pollution of water and air, the nature and degree of such pollution under different circumstances, and with different polluting agents, and the extent to which the methods at his disposal will enable him to detect and estimate these pollutions and the adulterations and impurities existing in the substances used as food.

The passing of the Public Health Act and of the Sale of Food and Drugs Acts has been attended by a very large decrease of adulteration and has greatly diminished the sale of inferior food, and of substances unfit for food, more especially in the metropolis and in the larger provincial towns. The work of the public analysts appointed under the provisions of the "Sale of Food and Drugs Act," is to a great extent hygienic, inasmuch as the samples submitted to them have to be examined not only with the view of determining whether they are of the "nature and quality demanded," but of ascertaining the presence or absence of substances injurious to health.

Many local authorities, however, have unfortunately not made full use of the powers possessed by them under these Acts, and on the other hand it has very frequently been extremely difficult to obtain a satisfactory punishment for a proved offence, even in the Metropolis. It is obviously very desirable that in all cases where an adulteration which actually is, or which may be under certain circumstances, dangerous to health, has been proved to exist in any article, a very severe punishment should be inflicted; for example, in the case of milk, an article on which infants and young children so largely depend for their nourishment.

It is not possible in a work of this kind to enter into a full account of the details of laboratory work, but a general idea can be given, and with this object it will be convenient to describe briefly some of the processes and apparatus made use of in hygienic investigations.

AIR.

The chief constituents of atmospheric air are:—oxygen, nitrogen, and carbonic acid; the first two in large quantity, the last in very small quantity. In 10,000 parts by volume of air, there are:

7,900	Nitrogen.
2,096	Oxygen.
4	Carbonic Acid.

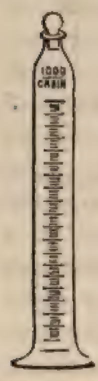
The amount of carbonic acid varies slightly in the pure air of places differently situated.

A number of substances are continually passing into the atmosphere,—gases, vapours and solid material particles. In all close and ill-ventilated places the air has become more or less charged with the products of combustion and of respiration—carbonic acid, water vapour, and foul "organic" matter—and it becomes therefore necessary to estimate the extent to which this pollution has taken place. The quantity of carbonic acid present may be taken as the measure of the degree of pollution of air. It has been shown that the diminution of oxygen and the increase of carbonic acid in the air of inhabited places are so slight as to be of very little importance in themselves, and that the dangerous pollution of such atmospheres is due to the presence of foul organic matter. Nevertheless, as the increase of carbonic acid is proportional to the degree of such foul organic pollution, and as the amount of carbonic acid is easily and very accurately determined by the process about to be described, the quantity present is taken as a measure of the degree of pollution.

Estimation of Carbonic Acid in Air.

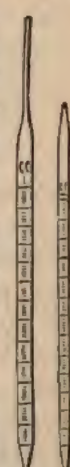
Pettenkofer's Process :—In this process, advantage is taken of the fact that carbonic acid unites with lime to form carbonate of lime, which is insoluble in water. Lime water is prepared by pouring pure distilled water over pure lime, and pouring off the clear solution from the sediment; and a rough method of estimating the quantity of carbonic acid is to place ½ oz. of this clear lime water into a 10½ oz. stoppered bottle containing the air to be tested, shaking it up and leaving it to stand. If the lime-water becomes turbid (from the formation of carbonate of lime), the air contains more than 6 parts of carbonic acid per 10,000 parts of air by volume. It has been shown that if the carbonic acid of an enclosed space exceeds that of the outer air by more than 2 parts per 10,000, the ventilation

of that space is insufficient, the fouling matter in the air being then in sufficient quantity to render the air perceptibly impure to the senses.

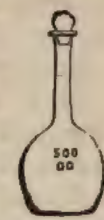

MEASURING GLASS.

The collection of a known volume of air for subsequent examination is carried out in various ways. The volume of a good-sized bottle of from two to six litres capacity and provided with a well-fitting stopper, may be taken by carefully filling it with mercury, and then measuring the volume of the mercury by pouring it into a *glass measure ;* and the air of any given place may be collected by filling the bottle with distilled water or mercury, and emptying it in the place in question, or by pumping the air into the bottle with a pair of bellows, or by previously pumping the air out of the bottle and then allowing the air to be tested to enter it.

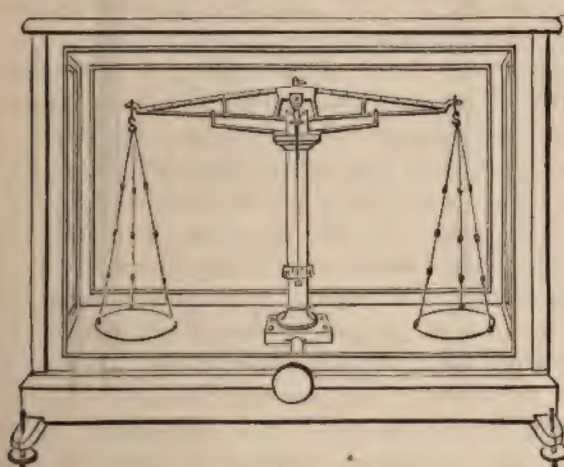
A measured volume of air having been obtained, an estimation of the carbonic acid is effected by absorbing it by means of a measured volume of lime water, the strength of which is known, and then determining the quantity of lime which has *not* combined with the carbonic acid. We thus know the quantity of lime which has entered into combination, and knowing further that exactly 56 parts by weight of lime unite with 44 parts by weight of carbonic acid, we arrive by a proportion sum at the number of parts by weight of carbonic acid present in the measured volume of air. The lime-water is measured out in a *pipette*, divided into cubic centimetres and tenths of a cubic centimetre. Its strength is determined by means of a "standard" solution of *Oxalic Acid*, which acid unites with lime to form oxalate of lime. A certain number of grammes of oxalic acid are exactly weighed out on a *Chemical Balance* dissolved in pure water to a definite volume, say 1 *litre* (1000 cubic centimetres) in a *graduated flask*, thus giving a solution, every cubic centimetre of


PIPETTES.

which contains a known weight of oxalic acid. Supposing the weight of oxalic acid in each cubic centimetre of solution to be exactly capable of uniting with one *milligramme* of lime (this being the usual strength of oxalic acid employed), it is clear that the number of cubic centimetres of oxalic acid solution required to exactly combine with or "neutralize" the lime present in a definite volume of a sample of lime water will be equal to the number of milligrammes of lime present in that definite volume. For instance, if 10 cubic centimetres of lime-water required 12 cubic centimetres of the oxalic acid solution to combine with all the lime, then the 10 cubic centimetres of lime-water will contain 12 milligrammes of lime in solution. The measured volume of lime-



GRADUATED FLASK.



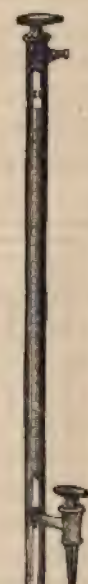
CHEMICAL BALANCE.

water is put into a convenient vessel and the oxalic acid solution added from a cubic centimetre *Burette* until all the lime is combined, a fact which is ascertained by employing an "indicator," such as the change of colour of *blue litmus paper* when brought into contact with an acid. So soon as the oxalic acid has combined with all the lime, the liquid in the test vessel turns the blue paper red. Instead of

litmus paper, litmus solution may be used in the above process; or again, paper coloured yellow with an infusion of *turmeric*, which is turned brown by alkalies such as lime, the brown colour disappearing when there is enough acid to neutralize the lime.

There are several modifications of the processes above described, by which with more or less accuracy the proportion of carbonic acid in air can be determined. The use of *baryta* water instead of lime-water is more convenient

BURETTE.



BURETTE.

and exact if proper precautions are taken. In accurate work of this kind, it is necessary to determine the temperature of the air examined and the barometric pressure at the time, in order to avoid the obvious errors due to change of volume produced by alteration of pressure and temperature.

Wanklyn's Process.—Good results may be obtained by making use of this process, which is thus carried out :—

From 2 to 3 litres of air (2000 to 3000 cubic centimetres)

are shaken up with a measured volume, say 100 cubic centimetres, of baryta water, which is rendered more or less turbid by the formation of carbonate of baryta. The solution is poured out into a cylinder made of thin glass, and the *degree of turbidity*, which is evidently proportional to the amount of carbonic acid present, is imitated in another precisely similar thin glass cylinder by mixing with another 100 cubic centimetres of the baryta water, measured volumes of a standard solution of carbonate of soda, which forms a precipitate or turbidity more or less pronounced according to the amount of carbonate added. The standard solution is measured from a burette and is made of such a strength that 1 cubic centimetre contains 1·97 milligrammes of carbonic acid (in combination with soda) which is equivalent to 1 cubic centimetre of carbonic acid.

Organic Matter.

Air always contains some organic matter, derived from animal or vegetable sources, or both. The precise nature of the organic substances is not accurately made out, but there is no doubt that those which are hurtful are chiefly nitrogenous.

Air loaded with organic matter possesses a peculiarly unpleasant odour, particularly evident in close, over-crowded rooms, and in narrow streets and courts. Prof. de Chaumont has shown that it is possible to graduate, by means of the sense of smell, the pollution of air by organic matter, with a close approach to the truth as indicated by the estimation of carbonic acid and by other chemical processes to be immediately described.

Attempts have been made to estimate the extent of organic pollution by means of permanganate of potassium, a salt which contains a large quantity of "available" oxygen, and which readily gives up some of its oxygen when placed in contact with organic matter, burning up the latter to a greater or less extent according to the nature of the organic substances present. The permanganate

dissolves in water, forming a deep purple solution. The process depends upon the extent to which a measured volume of the air will destroy the pink colour of a weak standard permanganate solution delivered from a burette. There may exist, however, in polluted air, other impurities which also decompose the permanganate, and the process is now only used as a qualitative test.

A common method for dealing with the organic matter in air consists in polluting a certain measured quantity of absolutely pure distilled water with a known volume of the air; and then subjecting the polluted water to analysis. The water may be most conveniently examined by the *ammonia process*, shortly to be described under the head of Water. Ammonia, viz., the gaseous compound of nitrogen and hydrogen, is very easily produced by the decomposition of organic matter containing nitrogen, and may thus be made an approximate measure of nitrogenous organic matter. In order that the ammonia process may be successful in the case of air, it is necessary that a large quantity of air be washed in as small a quantity of water as possible. This may be accomplished in different ways. By means of an *aspirator*, or vessel of known capacity filled with water, which can be run out by means of a stop-cock at the bottom, air is drawn through a flask or series of flasks containing pure re-distilled water free from ammonia, the volume of air which has passed through being obviously equal to the volume of water which has run from the tap of the aspirator. Or the air may be washed by injecting it, by means of a caoutchouc ball of known capacity, into a cylindrical vessel containing a little pure water with a spray-producing apparatus, and thus washing the air by means of a water spray.

Microscopic Examination.

The solid particles suspended in the air vary of course with the locality and with other circumstances. Mineral particles, salt, soot, fungi, starch granules, pollen, and vegetable spores may be detected in air. In the air of hospital

wards, pus globules, epithelium, and various forms of bacteria have been detected. The extent to which ordinary air is loaded with solid particles may be well observed by passing a beam of sunlight or of the electric light through a darkened room.

The collection of air-dust for microscopic examination is easily effected by drawing the air through a tube plugged with purified cotton wool or glass wool, by means of an aspirator. The wool acts as an efficient filter and the dust collected upon it may be examined.

Or a glass tube has one end connected with an aspirator and is provided with a small funnel at the other passing through a cork, and terminating inside the tube in a fine point ; opposite this point a thin glass disc moistened with glycerine is placed. The air being drawn in at the funnel strikes against the glass disc, which accordingly becomes coated with some of the suspended matters of the air, and may then be examined microscopically. Other plans are as follows :—

1. The air is drawn by means of an aspirator through a glass tube cooled by a freezing mixture. The moisture of the air is condensed and arrests some of the solid particles which thus remain inside the tube.

2. The air is filtered through pure *gun cotton*, the latter is then dissolved in alcohol and ether, and the dust left behind is examined. (Pasteur.)

3. Fine glass threads moistened with glycerine, arranged in the tube connected with the aspirator, are sometimes used as traps to catch the suspended matters.

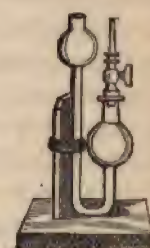
4. The "Montsouris" plan is also a good one. It is essentially the same as one previously described. The air passing through a small tube is made to impinge on a glass disc covered with glycerine and protected by a bell-jar.

The dust obtained by any of these devices is examined under a high microscopic power—a magnifying power of from 500 to 1000 diameters being generally used.

Metallic Poisons.

Both in the gaseous form and in the form of dust some metals and their compounds are occasionally found in the air. Copper and lead have been detected in the air surrounding smelting works, arsenic in the form of arseniuretted hydrogen, of Scheele's green (arsenite of copper) and of other compounds has been found in the air of rooms papered with arsenical papers. The wall-papers of suspected rooms and the dust deposited in them have therefore frequently to be examined. If a very large quantity of air containing arsenic be drawn through a tube heated to redness by a gas flame, a "metallic mirror," or ring of metallic arsenic will be formed in the tube, which is

MARSH'S APPARATUS.



MARSH'S APPARATUS.
(*Another form.*)

recognizable by its peculiar crystalline structure and by other tests. Wall-papers may be most satisfactorily examined by *Marsh's test.* The suspected paper is treated with warm hydrochloric acid, and the solution thus obtained is introduced into an apparatus evolving hydrogen, from pure zinc and pure sulphuric or hydrochloric acid, and provided with an exit tube terminating in a fine jet. The arsenic unites with the hydrogen forming arseniuretted hydrogen, which may be lighted at the jet, and burns with a peculiar bluish flame, the flame depositing on a cold porcelain plate exposed to it, a "metallic mirror" of arsenic.

Gaseous Impurities.

In addition to those already referred to there are several other gaseous impurities which may under some circumstances be present in the air. Those which are evolved from various manufacturing operations are as a rule very easy of detection.

The principal ones are :—

Carbonic oxide, carburetted hydrogen or marsh gas, sulphurous acid, sulphuric acid, sulphuretted hydrogen, ammonium sulphide, hydrochloric acid, chlorine, ammonia, nitric acid, and organic vapours (from sewage, bone-boiling, etc.)

The suspected, air containing one or more of these substances, having been collected as before described, special tests are applied to it with a view of recognizing the more common substances. Papers impregnated with

Blue litmus	reddened by acids,
Red litmus	blued by alkalies,
Turmeric	browned by alkalies,
Acetate of lead . . .	blackened by sulphuretted hydrogen,
Iodide of potassium and starch	blued by chlorine,

are slightly moistened and exposed to the air, either in the bottle, or are exposed under a glass shade to a stream of the air, which is made to pass through it by means of an aspirator or otherwise. A proper investigation must then be made by washing the air with distilled water, and examining the watery solution obtained.

WATER.

The ordinary waters used for drinking hold in solution a large number of substances. The purest natural water is obviously rain-water collected in the open country—inasmuch as it has merely passed through the air, and has not percolated through various strata or through surface soil more or less contaminated, and thereby become charged

with some of the substances contained in the strata or soils. Taking ordinary pure spring water, we have to deal with a solution containing several salts, dissolved gases (chiefly those of the air), and a small quantity of organic matter. Carbonates, sulphates, nitrates, and chlorides of lime, magnesia, soda, and potash, and silica, are the principal mineral substances held in solution; minute quantities of the salts of iron and alumina are generally present, but the number and the proportion of the constituents is of course somewhat variable. Organic matter derived from animal or vegetable sources, or both, and salts of ammonia, may be present in drinking waters, and constitute the points of most hygienic importance.

Drinking water may be polluted in very various ways by organic matter, as from cesspools, and leaking drains in proximity to the well, vegetable filth allowed to accumulate, house refuse falling into the well, or finding its way into it by means of unsound drains, or from foul air coming up the waste-pipe into the cistern; poisonous metals, such as lead or zinc may also be present, and occasionally the water may be found polluted chiefly with gaseous substances.

The object of the analyst in the case of water is, firstly, to determine the presence or absence of impurities; secondly, the nature and quantity of such impurities, and, thirdly, to form an opinion as to the wholesomeness of the water on the data he has obtained. The most important point, and the chief difficulty, is to deal with the organic matter.

Organic matter, though at a given time harmless, may at any moment become extremely dangerous, and so long as a water is polluted to any appreciable extent with organic matter it should be condemned. The taste and the smell of a water are first noticed, and its appearance and colour when viewed in a two foot tube placed on a white slab, so that the observer can look through two feet of the water; or when looked at in a decanter or flask capable of holding about a quart. Pure water should have no sweet, or salt, or other decided taste, and should be odourless. It

should be clear and colourless, or should have only a very faint tinge of blue in a two-foot tube. In some cases, however, a water may possess a decided colour, such as the water of Loch Katrine, and yet be perfectly fit to drink —but nevertheless, yellowish and brownish, and greenish-yellow tints are always to be regarded with suspicion.

The Solid Matter.—The total amount of solid matter is measured by putting a known volume of the water into a *platinum dish* capable of containing the whole volume of water with ease, and which has previously been carefully cleaned, heated to redness over a Bunsen gas flame, and weighed. The platinum dish is placed on a *water bath* and the water is evaporated off; the dish is then weighed again, and the difference between the two weights is evidently the weight of solid matter contained in the measured volume of water. This is calculated into parts per 100,000, or into grains per gallon. If the number of grains per gallon of solid matter is to be known it is convenient to evaporate 70 c.c. of the water, inasmuch as 70 c.c. of water contain 70,000 milligrammes, and there are 70,000 grains in a gallon, so that in 70 c.c. the milligramme corresponds to the grain in the gallon; the number of milligrammes of solid matter found in 70 c.c. of water will therefore be equal to the number of grains of solid matter in a gallon of the same water. The estimation of the quantity of solid matter present in a water is a point of great importance, polluted waters as a rule yielding much higher quantities than pure waters. Further information as to the solids may be obtained by heating the solid residue over a lamp, gradually raising the dish to a red heat. Water residues containing even small quantities of organic matter will perceptibly alter in colour, and those which contain much will brown and blacken very markedly. The loss of weight on "incineration" was formerly used as an approximate indicator of the quantity of organic matter present in the water, but several other constituents are volatilised at a red heat, *e.g.*, carbonic acid from the carbonates and chloride of sodium, so that the test is not applicable in this respect.

At the same time, the determination of the volatile matter often affords very valuable information.

In certain cases it is necessary to make a complete analysis of the solid constituents of water; this is the case with mineral and medicinal waters. A large volume of the water must be evaporated to dryness for such purposes—as much as one or two litres—the residue dissolved in acid, and the various constituents, silica, lime, magnesia, potash, soda, etc., carefully and completely separated, and weighed in convenient forms.

Chlorine.—The chlorine in water is present chiefly as chloride of sodium, or common salt. Chloride of sodium usually accompanies animal matters. Urine contains large quantities of it, and waters polluted with sewage are loaded with it; hence it follows that the proportion of chlorine present in ordinary pure waters being known, an estimation of the chlorine in any given water is a matter of great importance. Should the source of the water be near the sea, or should it be water which has passed through salt-bearing strata, the chlorine determination loses in value in consequence of the excess of salt which such waters contain, and further it must be pointed out that water may be highly and dangerously polluted with organic filth of *vegetable* origin, and may contain a very small quantity of chlorine.

The estimation of chlorine in water is a very simple matter. Advantage is taken of the fact that silver combines with chlorine in the proportion of 108 parts by weight of silver to 35·5 parts by weight of chlorine to form the white insoluble chloride of silver. A standard solution of pure nitrate of silver is prepared by dissolving a weighed quantity of the salt in a measured volume of pure distilled water—generally 4·79 grammes of nitrate of silver are dissolved in 1,000 c.c. or one litre of water—furnishing a solution, every c.c. of which contains exactly the amount of silver necessary to unite with one milligramme of chlorine—$Ag\ NO_3 + Na\ Cl = Ag\ Cl + Na\ NO_3$. 50, 70, or 100 cubic centimetres of the water are placed in a clean

white porcelain dish or in a *beaker* standing on a white slab, and the nitrate of silver delivered from a *burette*, with constant stirring of the mixture. The exact point at which all the chlorine present has united with the silver, is observed by means of a solution of pure *chromate of potassium*, a few drops of this solution having been placed in the water. Silver nitrate reacts on chromate of potassium to form chromate of silver, a blood-red substance. This it does so soon as it has united with all the chlorine present, for which it has a greater "affinity" than for the chromium, and the appearance of the faintest red tinge is an indication that the process is ended. The number of cubic centimetres is read off on the burette and is equal to the number of milligrammes of chlorine present in the volume of water operated on. This is by some calculated into chloride of sodium, or common salt, 35·5 parts by weight of chlorine uniting with 23 parts by weight of sodium to form common salt.

Oxidised Nitrogen.—Taken along with other evidence the presence and quantity of the *nitrates* afford very valuable information concerning the pollution of water. Nitrogenous organic matters decay and become oxidised and the nitrates are yielded by the process, so that supposing that the nitrates in a water do not come in any quantity from other sources they form a measure of the extent of nitrogenous organic pollution. By itself, however, the estimation of oxidised nitrogen is not to be taken as a trustworthy guide, any more than is the estimation of any other *single* constituent, or single product yielded by the constituents, of a water. Certain pure waters contain considerable amounts of nitrates, and a water may be highly charged with organic matter and yet contain but small quantities of nitrates. The estimation of oxidised nitrogen will frequently enable the analyst to discover that a water though not actually polluted is in danger of pollution at no distant date. A well drains the soil in its neighbourhood; should a cesspool or other source of filth be situated in the drainage area, the organic matters will percolate through the soil towards the well, and in passing through the soil these matters are in great part

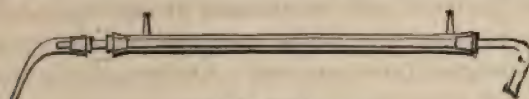
oxidised—nitrates being a product of the oxidation; the nitrates find their way into the well, and if the process continues, a time will come when the soil, being saturated with filth, is no longer capable of any purifying action, and the water of the well becomes highly polluted.

There are several methods for determining the quantity of nitrates. A measured volume of the water is treated with metallic *zinc* or *aluminium* and strong caustic potash, hydrogen is evolved and the nitrogen of the nitrate is thereby converted into ammonia. The mixture is distilled and the ammonia is determined in the manner immediately to be mentioned under saline and organic ammonia. Crum's method which is better, is essentially as follows:—A graduated tube open at both ends and provided with a stop-cock near to the top (see Figure) has the graduated part completely filled with mercury, the lower end dipping into mercury in a trough. A solution of the water-residue containing the nitrates followed by some sulphuric acid is introduced from the upper cup into the tube by means of the stop-cock; on vigorous shaking nitric oxide is given off, and its volume measured by means of the graduations. Corrections for temperature and barometric pressure being made, the amount of nitrogen is calculated from the volume of nitric oxide, and stated as nitric acid or as nitrogen in the form of nitrates.

CRUM'S TUBE.

Organic Matters.—The "Saline" and "organic" ammonia or the "free" and "albuminoid" ammonia, that is, the ammonia present in a water as such (free or saline), and the ammonia yielded by the destruction of the nitrogenous organic matter with an oxidising agent (albuminoid or organic), are taken as measures of the degree of pollution of the water. Most nitrogenous substances can be made to yield some of their nitrogen in the form of "ammonia," for instance *Urea*, the principal constituent of urine, is converted into carbonate of ammonia by the action of ferments in water, and thus the amount of free ammonia may be an important point.

A measured volume of water—generally half a litre—is placed in a *distilling flask* or a *retort*, which is then connected with a *Liebig's condenser*, a small amount of carbonate of soda having previously been added to the water. The latter is distilled and the distillates are received into measuring glasses in volumes of 50 cubic centimetres. These distillates are "Nesslerised." The first 50 c.c., for example, is placed



LIEBIG'S CONDENSER.

in its cylinder on to a white porcelain slab, and 2 c.c. of "Nessler's" solution added to it, and the mixture stirred up. Nessler's solution, which contains iodide of potassium, bichloride of mercury and caustic potash, strikes a yellow or deep brown colour with a solution containing a very minute quantity of ammonia—with large quantities a brown solid substance is obtained as a precipitate. The colour obtained is then imitated by means of a standard solution of chloride of ammonium (NH_4 Cl) containing the $\frac{1}{100}$ part of a milligramme or the $\frac{1}{100000}$th of a gramme in every cubic centimetre. A measured volume of this solution is mixed up with 50 c.c. of distilled water *free from ammonia* and 2 c.c. of the Nessler's solution added. The water having been distilled until no more ammonia is found by the Nessler test the distillation is stopped, and 50 c.c. of a strong solution of permanganate of potash and caustic potash are added, distillation is continued, and the distillates Nesslerised as before. The ammonia now obtained (organic or albuminoid) is that whose formation is due to the decomposition of the nitrogenous matters by the action of permanganate of potash.

The number of cubic centimetres of the solution of chloride of ammonium required to give the same tint as that obtained in any given distillate is obviously equal to the number of $\frac{1}{100}$ths of a milligramme of ammonia present in that distillate. The total amount of free and albuminoid ammonia yielded by the water is thus arrived at.

Combustion Process.—This process is too long and complicated to admit of its being fully described here. A measured volume of water, not less than one litre, is evaporated to dryness with certain precautions to avoid loss and gain; and the residue having been scraped up, is mixed with pure dry oxide of copper, introduced into a hard glass combustion tube, and heated strongly in a furnace. The copper oxide parts with its oxygen to the organic matter, which is destroyed, and the carbonic acid and nitrogen, which are the products of the combustion, are measured; the actual quantity of "organic carbon," and "organic nitrogen" present in a given volume of water are thus obtained.

It should be clearly understood that in all these processes it is necessary to adopt certain standards for guidance. In the case of albuminoid or organic ammonia, for example, the limit 0·15 parts per million, meaning thereby 0·15 parts of ammonia (grammes, ounces, &c.), yielded on distillation by one million parts (grammes, ounces, etc.) of water, has been fixed upon as the result of experience. Pure waters known to be uncontaminated not yielding *more* than this amount, and polluted waters not yielding less. If we find less than 0·1 parts per million of albuminoid ammonia *other evidence to the contrary being absent* we conclude that the water is not polluted; for in order that such a water may be polluted it is necessary to assume in the first place that it was originally of very exceptional purity, and secondly, that the pollution had taken place to an extent far slighter than occurs in almost every case where there has been any pollution at all.

A limit of some kind, determined in a similar way, must of course be used in any process. Other things being equal for example, the solid residue of a water should not rise much beyond 40 or 50 grains in the gallon. The limits for organic carbon and organic nitrogen are of course also based on experience.

Microscopic Examination.—This is a most important part of the hygienic examination of water and should never be omitted. The usual mode of obtaining the suspended

matter in water for microscopic examination is to allow some of the water to settle in a good sized conical glass, the sediment being taken out with a pipette. A *stop-cock* flask or *straight burette* can also be used for the purpose, and these are in some respects more advantageous. The presence of fibres of cotton, wool, silk, etc., is evidence of pollution with house refuse. Bacteria of various kinds, fungoid growths, epithelium and muscular fibres may be detected, the conclusions to be drawn from the presence of such substances being obvious.

Poisonous Metals.—The metals which may be present in drinking water and which have to be considered as regards their poisonous action, are lead, copper, zinc, and iron. The presence of an excess of lead, iron, or copper is at once detected by placing 70 c., or 100 c.c. of the water in a clean porcelain dish and adding two or three drops of sulphide of ammonium. If the water contains more than $\frac{1}{10}$ of a grain of these metals per gallon a more or less dark coloration is produced, due to the formation of the sulphides of lead, copper or iron. Zinc, which appears to be not unfrequently present in water, has to be sought for in a strong solution of the residue of the water, the sulphide being white.

Hardness.—A water is said to be "hard," when it contains a considerable amount of the salts of lime and magnesia, and to be soft when these salts are present in but slight quantity. The softest natural water is of course rain-water; among the hardest are those proceeding from springs in chalk formations. The salts of lime and magnesia decompose *soap*, and hence a hard water requires a much larger quantity of soap than a soft water to form *a lather*—a lather being only possible when undecomposed soap is present. The degree of hardness of water is determined by means of a standard solution of soap, of such a strength that 1 cubic centimetre of it contains the amount of soap that will be decomposed by one milligramme of lime. 50 or 70 c.c. of the water are placed in a stoppered bottle, the soap solution added, and the bottle vigorously shaken after each addition until the point at which a permanent lather

begins to form is reached. The number of cubic centimetres of soap is then equal to the number of milligrammes of "hard" salts in the water: one cubic centimetre is deducted as it is found that 70 c.c. of water itself consumes that amount of soap solution.

Temporary and Permanent Hardness.—By boiling a measured volume of the water for some time, the dissolved carbonic acid is driven off and the carbonate of lime and other salts held dissolved by the carbonic acid are deposited in the form of a crust. The number of c.c. of soap solution, less one, required to produce a lather in the water after it is boiled, gives the amount of permanent hardness, and the difference between this and the total hardness is equal to the temporary or removable hardness.

An approximate opinion as to the hygienic quality of a water may be arrived at without going through a series of accurate quantitative operations.

A number of tests may be applied to the water as follows:—

1. The reaction of the water is taken with litmus papers to note any acidity or alkalinity.

2. About 25 c.c., of the water are boiled with a solution of chloride of gold. In proportion to the amount of organic matter present the gold is thrown down as a blackish powder.

3. About 100 c.c. of the water are treated with a few drops of very weak permanganate of potash solution, and allowed to stand; the extent to which the permanganate is decolorised is judged of by adding the same number of drops to the same volume of pure distilled water.

4. To about 50 c.c. of the water about 2 c.c. of Nessler's solution are added, and the colour produced is compared with that obtained in the same volume of pure distilled water similarly treated.

5. Nitrate of silver solution is added, and the amount of precipitated chloride of silver observed.

6. About 50 c.c. of water are evaporated to dryness and the residue heated to redness, and the extent to which blackening or browning takes place is noted.

7. To about 25 c.c. of the water are added a few drops of a solution of brucine and a little pure sulphuric acid. If nitrates are present (even in very small amount) a pink colour of greater or less intensity is produced.

8. Oxalate of ammonia solution is added and the lime is precipitated as oxalate of lime. The amount of the precipitate is noted.

9. Barium chloride solution, with a little nitric acid, is added, and the sulphates present are precipitated as sulphate of barium.

10. Finally the water may be tested for phosphoric acid by means of a solution of molybdate of ammonia and nitric acid, and boiling after their addition. The presence of phosphates is indicated by a yellow coloration, and a yellow precipitate.

FOODS AND DRINKS.

The hygienic analysis of food includes the determination of the composition of the chief natural and artificial foods in their natural and pure state, the detection of alterations, of impurities and of adulterations, and the estimation of the extent and amount of these should they exist. It is obvious that in order to form a satisfactory opinion as to the dietetic value of a given food, as to its general quality, and as to whether it has in any way been altered or falsified, a knowledge of its normal composition, and in the case of an artificial mixture, of the normal composition and properties of its constituents, should be as far as possible obtained.

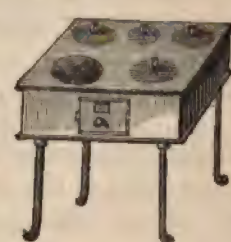
The matter of greatest importance consists in separating and in estimating the quantity of the *proximate* constituents. The proximate constituents of a substance are the various definite chemical compounds entering into its composition, whereas by its *ultimate* constituents are meant the elementary bodies which build up these compounds. For example, the chief *proximate* constituents of milk are:—water, fat, caseine, milk-sugar, mineral matter (including common salt and phosphate of lime); the principal

ultimate constituents being the elements oxygen, hydrogen, carbon, nitrogen, calcium, phosphorus, sodium, and chlorine.

The isolation and the determination of the respective total quantities of the ultimate constituents of such a substance as milk is a comparatively easy matter, but we do not thereby obtain very much information as to its value as a food, or as to the purity or non-purity of a particular sample of it, such information being rather obtained by a study of its proximate constituents.

In greater or lesser quantities the following substances and classes of substances enter into the composition of the great majority of foods:—Water, mineral matters

AIR OVEN.



WATER BATH.

(such as common salt and the carbonates and phosphates of lime), fats and oils, sugars, starches, cellulose or woody fibre, gums, nitrogenous compounds (such as caseine in milk, gluten in bread, gelatine, etc.), and alcohol.

In addition certain foods have of course certain specific and characteristic constituents, to which reference will be made.

Water.—The amount of water in a substance may be accurately determined by carefully weighing out a small quantity in a convenient vessel, such as a platinum, porcelain, or glass capsule, and heating it by steam on a *water-bath* or in an *air oven*, until it ceases to lose weight. The final weight deducted from the weight of substance taken gives the quantity of moisture contained in that weight. The employment of this method pre-supposes that the substance under examination is not altered or affected

by the heat to which it is exposed, except as regards the loss of the water it contains. Means are of course taken to dry the substance in a condition which shall ensure the loss of its moisture with the greatest facility. As a rule, it is powdered and arranged in as thin a layer as possible in the evaporating vessel. It is occasionally necessary to dry in a vacuum at the ordinary temperature of the air, this being generally accomplished by placing the substance under the receiver of an air-pump together with a vessel containing strong sulphuric acid, a body which possesses the property of absorbing water-vapour with great avidity.

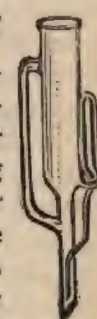
Mineral Matter.—The total amount of mineral matter is approximately determined by burning a weighed quantity of the substance to be examined, and weighing the amount of ash obtained. It must be borne in mind that some mineral substances, such as common salt, are volatilised at a very high temperature, and that some, such as carbonate of lime, are partially decomposed by loss of carbonic acid, but the estimation of the percentage of ash yielded affords valuable information as to the impurities and adulterations that may be present in certain foods. The amount of substance taken for examination is regulated by the quantity of ash that different foods are known to yield, and the burning off of the organic constituents is always managed at as low a temperature as possible.

Analysis of the Ash.—An analysis of the ash is sometimes called for and, as in the case of the analysis of the solid residue of a water, is carried out by separating the different constituents from a given weight of the ash and weighing them. . For example, valuable indications are afforded by determining in the ash of milk, the percentage of chlorine and of phosphates ; in the ash of beer, the percentage of common salt ; in the ash of coffee-mixtures, the percentage of silica, and in most ashes the proportion of matter soluble in pure water to matter not thus soluble.

Fat.—To estimate the quantity of fat, advantage is taken of the fact that certain organic liquids, such as *ether*, possess the property of dissolving fat, and of depositing it

when they are evaporated. A weighed quantity of the substance—which may previously require some preparation, as in the case of milk, from which the larger part of the water must first be removed—is digested with ether at the boiling temperature of that liquid, this treatment being continued until the whole of the fat has been extracted ; the etherial solution is passed through filtering paper, received in a previously weighed vessel, such as a platinum dish, and the ether evaporated off by immersing the vessel in hot water. The increase in the weight of the platinum dish is the weight of the fat. A very perfect extraction of fat, by means of ether, may be secured by placing the substance in a flask provided with an upright condenser, covering the substance with ether or other volatile extracting liquid, and boiling the latter. The vapour of the ether being condensed, falls back into the flask, and a very concentrated solution of the fat may thus be obtained. A *Soxhlet's extractor* is a convenient apparatus for such purposes—as large a quantity of fat as possible being dissolved in as small a quantity of ether as possible, a point of much importance as regards facility and rapidity of work.

FLASK, WITH UPRIGHT CONDENSER.



SOXHLET'S FAT EXTRACTOR.

Sugar.—There are a great many processes for the estimation of sugar, both chemical and physical. The amount of carbonic acid evolved during the alcoholic fermentation of a saccharine substance has been proposed and used as a measure of the quantity of sugar to which the fermentation is due ; and the specific gravity of the saccharine liquid has also been used to estimate the percentage of sugar. These two processes are not, however, now in use ; the most usual method is perhaps that of Fehling. This process depends upon the action of grape sugar (or glucose) on sulphate of copper in the presence of a

strong alkali. Certain organic substances, grape sugar among the number, possess the property of influencing several chemical reactions. If caustic potash solution be added to a solution of sulphate of copper, a bluish precipitate of hydrated oxide of copper will be produced—and if the mixture be boiled it will become black, owing to the formation of the black oxide of copper. But should the smallest portion of grape sugar be present, on boiling, the mixture will become red to reddish brown in consequence of the formation of the red sub-oxide of copper, a substance, as its name implies, less highly oxidised than the ordinary oxide. A standard solution of sulphate of copper with strong caustic potash is prepared of such a strength that each cubic centimetre contains the quantity of copper that will be exactly reduced to the sub-oxide by the action of 5 milligrammes = ·005 grammes of pure grape sugar. A known volume of the solution of copper is placed in a white porcelain dish, is heated to boiling and the saccharine liquid delivered into it from a burette, until the whole of the copper has been converted into sub-oxide, as is shown by the point of disappearance of the blue colour of the solution in the dish.

Cane-sugar has no action on the solution of copper; but its quantity may nevertheless be determined by it, inasmuch as by boiling a solution of cane sugar with a few drops of acid, the cane sugar is converted into grape sugar. The sub-oxide of copper precipitated by a measured volume of grape sugar solution may also be separated, washed, dried and weighed, and is of course a direct measure of the quantity of grape sugar which has precipitated it.

Starch and *Woody-fibre* may also be estimated by taking advantage of the fact that by prolonged boiling with acid they are converted into a substance which is chemically identical with grape-sugar or glucose, and reacts on the copper solution in a precisely similar manner and to the same extent. It must, however, be understood that should both these substances be present in the material under examination, this method enables no distinction to be made

between them, and their separation must be effected in other ways. Where the complete separation of a number of chemically similar substances is required, the difficulties of the problem are of course greatly increased, and methods more or less complicated must be devised to cope with it.

Starch.—The chemical composition of the various starches is identical, although the forms of the granules, or corpuscles, differ greatly according to the plant from which the starch comes. It may be estimated by the process above mentioned. The specific characters of the granules of starch from different plants are very easily made out by the microscope, and fairly close approximations may be made to the true percentages of starch in certain mixtures—such, for instance, as mustard and flour, or cocoa and arrowroot, by making up mixtures of known quantities of the starch in question with pure mustard, pure cocoa, etc., as the case may be, and counting the number of starch granules in miscroscopic preparations of the same quantities of both the standard and the suspected substances.

Starches are all coloured intensely blue by iodine, and the latter substance is accordingly employed as a very delicate test for the presence of starch. Granules of starch under the microscope may thus be identified with the greatest ease.

Of non-nitrogenous bodies we have examples in the fats and the carbo-hydrates (sugar, starches, gums, etc.), all of which are compounds of carbon, hydrogen, and oxygen alone.

Nitrogenous Compounds.—Nitrogen is present in food-substances combined with other elements in a great variety of ways, forming a number of more or less complicated compounds; and several classes of nitrogenous bodies have accordingly to be distinguished. For example, of the compounds of carbon, hydrogen, oxygen and nitrogen alone we have some of the *alkaloid class* such as theine in tea and coffee, and theobromine in cocoa. These bodies act as strong poisons on the animal economy. The most

important nitrogenous bodies as regards food, however, belong to the so-called *albuminous* class, which, in addition to the elements mentioned, contain sulphur, and in some cases phosphorus. Such for instance as casein in milk, gluten in the cereals, albumen (white of egg) and fibrin in blood, flesh, etc., and vegetable albumens. Gelatine obtained from skin, tendons, and bones, belongs to another sub-class.

Our knowledge of these substances is still extremely imperfect. Many of them, formerly regarded as separate and definite compounds, are now well made out to be mixtures of several. The absolute separation and estimation of many of these compounds is therefore not always possible in the present state of our knowledge with regard to them; and it has consequently been usual to estimate the total quantity of nitrogen contained by the body under examination, that quantity being a measure of the total amount of nitrogenous matters present.

Such a determination may be carried out by mixing a carefully weighed portion of the dried substance with oxide of copper, introducing the mixture into a long tube of hard glass, and having removed the air from the latter by means of a pump, heating it to redness in a furnace. The nitrogenous substance is decomposed, and the nitrogen is evolved and measured, by allowing it to bubble up into a graduated tube filled with mercury and standing in a bath of mercury; corrections for temperature and barometric pressure being of course made.

In thus determining the total nitrogen in a substance used as food, or in any particular portion of such a substance, we are not justified in assuming that the whole of the nitrogen is present in such combinations as are valuable for feeding purposes, such, for example, as the albumens. Much of the nitrogen *may be* present in compounds which are comparatively valueless as foods, and in order to obtain further information as to the state of combination of the nitrogen, it is necessary to employ some process for the estimation of albuminous matter. Such processes depend as a rule upon the property possessed by most

albumens of *coagulating* when treated with acids or other re-agents.

Alcohol.—In the examination of beverages, the determination of the percentage of alcohol is generally the first step taken. There are several very accurate methods. Pure or absolute ethylic alcohol is a mobile, colourless, and neutral liquid of specific gravity 0·815 at 0° Centigrade and boiling at 78·3° Centigrade. The alcohol in an alcoholic liquid is extracted by distillation. One hundred cubic centimetres or more of the liquid, (beer, wine, spirits, etc.), are placed in the distilling apparatus and distilled until the matters in the retort or flask are nearly dry. The distillate having been received in a flask fitted air-tight to the end of the condenser is made up to the same volume as the volume of liquid experimented on (100 c. c. or more, as the case may be,) with distilled water. The specific gravity of this distillate at 0° C. (32° Fahrenheit) is then accurately taken in a specific gravity flask. Inasmuch as bulk for bulk alcohol is lighter than water, as ·815 is to 1, it follows that the more alcohol there is in the distillate the weight of the latter will be *pro tanto* lessened. A hydrometer is also frequently used for this purpose; it consists of a glass tube with a weighted bulb, which sinks in the liquid to a depth varying with its density, the latter being indicated by graduations on the stem. Tables have been constructed giving the specific gravities of mixtures of alcohol and water in all integral proportions, and by referring to one of these the amount of alcohol in the 100 c.c. of distillate is at once seen. Since the distillate has the same volume as the liquid experimented on, and since all the alcohol in the latter is contained by the distillate, the percentage of alcohol required is arrived at.

SPECIFIC GRAVITY FLASK.

HYDROMETER.

We now proceed to describe and explain some of the simpler processes of food-analysis, more particularly those which are of hygienic interest.

Milk, Cream, Butter, and Cheese.—The milk of different animals varies somewhat in composition, so far as the actual percentages of the typical ingredients are concerned; but the milk of any healthy animal, such as the cow, even when the methods of feeding are different, varies within well-ascertained and tolerably narrow limits, so that the analyst, knowing the average composition of the milk of healthy cows, can find whether, in a particular case, there is a departure from it. We are not for the moment concerned with departures from the normal composition, such as those which occur in milk from diseased or starved animals, or with milk which for other reasons is of abnormal character. By determining the total quantity of solid matter, of fat, of sugar, of caseine (curd), and of ash, as well as the specific gravity, the analyst is able to ascertain whether milk has been sophisticated by abstracting fat (cream), or by adding water, or by both these processes. It must be remembered that these sophistications may be of a very dangerous character. Milk is admitted to be a perfect food for the young, containing as it does a proper proportion of the ingredients of a typical food, viz., the nitrogenous, saccharine, and mineral constituents, and the lowering of its value as a food has been shown to have much to do with infantile mortality; on the other hand, the water with which a milk is adulterated may be, and very often has been polluted, and the poisons of various diseases, which find a congenial soil in such a substance as milk, are thus often carried over a wide area, and may produce their specific effects in a large number of persons.

The normal composition of healthy cow's milk, having a specific gravity of 1029 and upwards, is as follows (Parkes):—

Water	86·8
Albuminates	4·0
Fat	3·7
Carbohydrates (sugar)	4·8
Salts	0·7
	100·0

According to Wanklyn, there are in 100 c.c. of average country milk :—

Water	90·09 grammes
Fat	3·16 „
Caseine	4·16 „
Milk sugar	4·76 „
Ash	0·73 „
	102·90 „

Specific Gravity.—Considering milk as a watery solution of lactin (milk sugar), caseine and salts (*i.e.*, compounds of magnesium, potassium, sodium, and iron, with chlorine, and with phosphoric and sulphuric acids), holding fat globules in suspension, it seems at first sight that the addition of more water should lower the weight of a given volume of milk, and hence lessen the specific gravity. The fact that fat is lighter than water must, however, not be lost sight of, and that, in consequence, increase of fat means lowering of density. The commonest instrument used in examining milk by a specific gravity test is that known as the *Lactometer.* This is simply a hydrometer applied to milk—a bulb-tube and stem weighted at the bottom. It is floated in the milk and it will sink more or less, according to the density of the liquid in which it is immersed. The lactometer may be graduated, by marking on the stem the points to which it sinks when it is placed in mixtures of normal milk with water in different proportions, or it may be graduated into specific gravities. As a matter of fact the lactometer is a very untrustworthy instrument. A more accurate method is to fill a specific gravity flask with the milk and weigh it at a particular temperature. By comparing this weight with that of the same flask filled with pure water at the same temperature the density of the milk is obtained. The specific gravity of pure milk varies from 1023 to 1035, the average being 1029. The total amount of solid matter may be determined by drying up on the steam bath, about five grammes

LACTOMETER.

of milk weighed out in a platinum capsule, and by burning this residue the percentage of ash (mineral matter) is arrived at. The amount of solids yielded by pure milk varies from 11·5 to 14 per cent.; when the percentage falls below 11, the milk is very poor, and has probably been sophisticated. The fat is obtained by extracting about 10 grammes of the milk, previously evaporated to a semi solid consistence, by means of ether; the solution of the fat in the ether, passed through a filter and collected in a weighed vessel, is evaporated in the latter until the whole of the volatile solvent has disappeared, and the weight of fat thus obtained.

After the extraction of fat there remain caseine, milk-sugar and mineral matter. By treatment with alcohol and water the milk-sugar, and part of the ash are removed; the residue consists of caseine and a little phosphate of lime, which may be dried and weighed, burnt, and the ash weighed; the latter, deducted from the first weight, gives the quantity of caseine. The milk-sugar may be determined in the weak alcoholic extract above mentioned, by means of Fehling's copper solution, as previously described under "Sugar"; or a given weight of milk may be "coagulated" with acetic acid, and the clear whey may be taken for the determination of sugar. The "solids not fat" that is, the caseine, salts, and lactin, obtained by direct experiment or by deducting the percentage of fat from the percentage of total solid matter, is a fairly constant quantity, *i.e.*, is not subject to the variation of the single constituents. This percentage is taken at 9·3, and knowing that 100 parts by weight of pure milk will yield 9·3 of "solids not fat," it is of course possible to calculate how much pure milk there is in any particular sample.

CREAMO-METER.

The percentage of cream thrown up by milk in a given time, is determined by an instrument called a *creamometer*. This is a long tube in which the milk is allowed to stand and which is graduated to give percentages.

Many ingenious adulterations of milk have been devised and

practised with a view of increasing the difficulty of detecting fraud by analysis, but they are all susceptible of detection by some modification of the processes just sketched out, and it cannot be too widely known that attempts to cheat the analyst, however clever they may be, can only in the long run result in failure. Among the other adulterations of milk the following have to be guarded against, most of them, however, being extremely rare; starch and gum (to conceal thinness), annatto or turmeric (to give colour), glycerine, syrup, emulsions of seeds (almonds, &c.,), chalk, sodium carbonate.

Apart from the discovery of adulteration in milk, its characters when it has been altered by decomposition, or when it has been obtained from starved or diseased animals, have to be considered. The alterations in chemical composition, although in some cases very striking, are not as yet sufficiently made out to be distinctive, and the microscopic appearances are therefore chiefly to be relied upon. Milk from diseased animals soon decomposes. Blood discs, pus cells and fungoid growths can be at once detected by the microscope. The characteristic appearance of the so-called "blue milk" is due to a microscopic growth. Minute moving organisms have occasionally been detected in milk from suspicious sources. A peculiar clustering of the milk corpuscles is noticed in certain diseases.

Cream.—The composition of cream is similar to that of milk, except that it contains a much larger amount of fat. The following is the analysis of a very thick cream (Wanklyn):—

Water	50·00
Fat	43·90
Caseine and Milk Sugar	5·63
Ash	0·47
	100·00

It has been found adulterated with starch and gum, as well as with mineral matters. White of egg has also been used. The analysis is carried out in the same way as in the

case of milk, but is somewhat more difficult owing to the large amount of fat. It hardly enters into the scope of the present work to describe the necessary analytical modifications which must be applied in the case of cream.

The analysis of condensed and prepared milks and milk foods, is also beyond our present scope. In these cases the addition of large quantities of cane-sugar for the purpose of preservation, considerably complicates the methods employed.

Butter.—Butter consists principally of cohered milk fat. It contains varying quantities of salt, water, and caseine. The following is an analysis of a pure butter.

Fat	83
Curd	5
Salt (ash)	3
Water	9
	100

The average amount of water varies from 5 to 10 per cent., but may be much higher even in genuine butter. For the purpose of increasing weight, butter is beaten up with water; an excess of the latter can be detected by drying a given weight of the butter on the water bath. By simply melting the butter in a narrow tube, the fat rises to the top, the water, containing the salt in solution, and the curd, sinking to the bottom; if the amount of water is very large, this test makes the fact at once evident. Butter may also be loaded with an excessive amount of common salt. This may easily be determined by extracting with water, and estimating the quantity of salt in the solution, by means of standard nitrate of silver as in the analysis of water. The most important point, however, is the substitution of some cheaper fat. Butter fat is a mixture of the Glycerides of certain fatty acids, some of which, viz., Palmitic, Stearic and Oleic acids, are insoluble in water, and not volatile; the others Butyric, Caproic and Caprylic Acids being soluble and volatile. For detecting and estimating foreign fat,

advantage is in the first place taken of the facts, (1), that butter-fat possesses a different specific gravity to that of other fats, and (2), that it melts at a different temperature.

The fat having been separated by melting in the narrow tube and filtering it through coarse filtering paper into a dry bottle, the specific gravity may be determined by the flask as in the case of milk. The melting point, by drawing some of the melted fat into a very thin and narrow tube, allowing it to congeal therein, and placing it in a beaker of water, together with a thermometer. The beaker is nested in a second containing water, to which heat is then applied, and the temperature at which the fat *runs up the tube* is noted on the thermometer. Another valid plan is to note the temperature at which a small glass bulb will sink in the fat to be tested.

By determining the percentage of insoluble fatty acids, the analyst is able to calculate the extent to which a sample of butter has been sophisticated with foreign fats. The fatty acids insoluble in water are tolerably constant in butter fat, being about 88 per cent. of its weight, most other fats yielding about 95·5 per cent.

A given weight of the fat is "saponified" by heating with caustic potash and alcohol; the process of saponification consisting essentially in the combination of the fatty acids with potash, to form compounds called *soaps*. Some of the more volatile substances being driven off by the heat used in the process. The soap obtained is decomposed by sulphuric acid, preferably in a 'butter-flask,' a modified separating flask, and the resulting mass of fatty acids washed with hot water, the washings being allowed to escape by means of the stop cock.

The insoluble fatty acids are thus obtained in the flask in the form of a cake, which can be dissolved in ether, the solution collected in a weighed dish, the ether evaporated, and the fatty acids weighed. The soluble fatty acids may also be separately estimated.

In most samples of butter which contain foreign fat, the specific gravity, the percentages of insoluble and soluble

fatty acids, and the melting points, are all entirely different from those obtained with genuine butter. For instance, genuine butter contains about 6 per cent. of soluble, and 88 per cent. of insoluble fatty acids, whereas "butterine" contains only 0·6 per cent. of soluble, and 95·5 per cent. of insoluble fatty acids.

Cheese.—Cheese is made from milk by coagulating the caseine by the action of *rennet*, and pressing the mass obtained. It is not a much adulterated article; but it is of importance occasionally to examine the rinds for poisonous metals, not only because of the custom of using protecting foils containing lead, but also because arsenical and other metallic solutions have been applied in order to prevent the attacks of insects. The examination of cheese is carried out in the same way as that of milk and butter.

Wheat Flour and Bread.—The following is the composition of wheat flour of average quality:—

Water	16·5
Fat	1·2
Gluten, &c.	12·0
Starch, &c.	69·6
Ash	0·7
	100·0

Bread is flour made into a paste with water, treated with carbonic acid gas, which is liberated in the paste, either by the action of yeast, or by mixing it with a strong solution of the gas in water; and subsequent baking.

The colour, smell and taste of flour and bread often yield valuable information as to quality; indeed, these tests are valuable in the examination of all food substances. The microscope detects the presence of fungi, of which several have been found in flour, and which also occur in bread; their presence indicating that the article is diseased or damaged. Certain animal parasites are also found in bad flour; and a point of much importance is the detection of adulteration with other starchy substances. The characteristic

appearances of the different starches under the microscope enables this to be done with ease in the case of flour; but with bread, inasmuch as the process of manufacture alters these appearances, the starch granules swelling and bursting, the problem is much more difficult.

The chemical examination of flour resolves itself chiefly into determining the percentages of Water, Gluten, Ash, and the presence of Alum, and its quantity, if present.

The amount of water in flour is ascertained by drying one gramme in a dish, and the amount of ash by burning two or three grammes. For bread larger quantities are necessary. The more water the less is the value of the article; flour should be rejected if it contains more than 18 per cent. If the ash be more than 2 per cent. mineral adulteration or impurity is present. An easy method of detecting large quantities of mineral impurity is to shake up the flour with chloroform, when the flour floats, and the foreign mineral impurities fall to the bottom of the vessel. Gluten is estimated in flour by washing away the starch from a weighed quantity: good flour contains from 8 to 12 per cent.

Alum in Flour and Bread.—The presence of alum is most easily detected by treatment with a tincture of logwood and carbonate of ammonia. If alum is present, a blue or green colouration is obtained; the flour should previously be well mixed with water and the bread should be allowed to dry. If a blue colour be obtained a further examination is necessary, and the exact amount of alumina present must be separated out from a weighed quantity of the flour or bread and weighed. The process is a somewhat long one, and it will hardly be necessary to describe it here.

There have been rare cases of poisoning which have occurred through the presence of lead in flour, which has been introduced through the repairing of mill stones with lead. Arsenic has also been found in flour, having been introduced accidentally, and plaster of Paris (sulphate of lime) has been fraudulently sold with flour.

Tea, Coffee, Cocoa and Chocolate.—The examination of tea does not present much difficulty. The presence of foreign

leaves, of sand, and other mineral substances, and the use of exhausted leaves are the chief points to be seen to. The Chinese themselves have invented a method of adulteration which consists in steeping the leaves in gum and rolling them in sand. This they call "lie tea"; and most samples of the cheaper kinds of tea contain small quantities of it.

The tea to be examined is boiled up with water, and the leaves can then be picked out and examined. The structure of the tea leaf is very characteristic. The shape, serration, and the venation, especially the latter, being distinctive. The primary veins run out from the mid rib nearly to the border, and then turn up sharply. Foreign leaves can therefore be at once detected by their special characters. The vessel in which the tea has been boiled will contain any sand or mineral substances which may have been adhering to the leaves. The chemical examination of tea essentially consists in the determination of Water, Ash and Soluble Ash, Extract, Theine and Tannin. The extract is obtained by treating a weighed quantity of tea with hot water and evaporating a measured bulk of the solution to dryness, and weighing the residue. If exhausted leaves are present, the amounts of extract and of ash soluble in water, &c., will be obviously lower than those obtained from good tea. The amount of the total ash will be high in case of the presence of much mineral impurity.

Coffee.—It is of course in the ground state that coffee is most liable to adulteration. The chief adulterations are chicory, roasted wheat and beans, acorns and burnt sugar. By far the most common is chicory. The analysis of coffee is very similar to that of tea. Chicory may be detected by the microscope, its dotted ducts and large loose cells being very characteristic. If coffee containing much chicory be sprinkled on the surface of some water in a jar the chicory will sink, colouring the water a deep brown as it does so. Pure coffee gives a hardly perceptible colour to the water, and scarcely sinks at all. The alkaloid of coffee, viz., caffeine, is identical with theine.

Cocoa and Chocolate.—These articles, as they come before the analyst, are "prepared," and are subject, consequently, to various adulterations. The various forms of prepared cocoa are simply the ground seeds previously roasted and deprived of their covering, and mixed with starch and sugar. The microscope at once shows the nature of the mixture. There is no essential chemical difference in the composition of cocoa and chocolate. Both cocoa and chocolate are rich in fat.

Alcoholic Beverages.—This is a very wide subject, and cannot be more than alluded to here. In all cases, of course, the determination of the quantity of alcohol is the first essential point. There are several methods, the one most usually employed being as follows: A measured volume of the liquid is distilled, and the distillate made up to the same volume as the liquid taken. As previously explained, the specific gravity of the distillate at once gives the percentage of alcohol present by reference to a specific gravity table.

Special adulterations and impurities, as might be expected, have to be looked for in different beverages, *e.g.* artificial colouring matters in wine, bitter principles and salt in beer, "fusel oil" (amylic alcohol) in spirits. The addition of water to spirits is a criminal offence, but so far as health is concerned it is perhaps an advantage.

Condiments—Vinegar, Pepper, Mustard, Pickles.—Vinegar is more or less impure acetic acid. It contains from 3 per cent. to 5 per cent. of acetic acid (glacial); 3 per cent. is the minimum allowable. It is adulterated, (1), by the addition of water, (2), of sulphuric acid or other strong mineral acid, and it may contain lead, copper, or zinc, due to the action of vinegar on the vessels in which it has been kept, or on the apparatus used in its manufacture.

By taking the specific gravity the addition of water can be detected. It is preferable to distil a measured bulk of the vinegar, and to take the specific gravity of the distillate. The percentage of acetic acid is then obtained as in the case of alcohol.

The total acidity of the vinegar may be determined by means of a standard alkaline solution. The acidity is calculated as acetic acid, although other acids may be present. If the specific gravity is low and the acidity high, sulphuric acid or some other mineral acid may have been added. The processes for determining the amount of free sulphuric acid in vinegar cannot be detailed here. It may be pointed out that the ordinary methods of estimating sulphuric acid, by precipitation and weighing as sulphate of barium, do not admit of differentiating between the added sulphuric acid and natural sulphates in the vinegar. However, there is a rapid qualitative test which may be easily applied:—10 c.c. of vinegar are evaporated to dryness and burnt; the ash is then dissolved in a little water, and the reaction of the solution taken with litmus paper. If the ash is alkaline the vinegar cannot contain an excess of free sulphuric acid, if *neutral* it very likely does, the reason being, that the ash of natural vinegar consists chiefly of alkaline carbonates, but if excess of sulphuric acid is present, neutral salts will be obtained in the ash, owing to the decomposing action exerted by the sulphuric acid during evaporation.

Pickles.—The vinegar used may be examined as has just been described. The presence of such metals as copper and lead, and their quantities if present, can be determined by incinerating a given weight and using the ash for analysis. The presence of copper in pickles can be detected by inserting the bright blade of a steel knife, on which the metal is deposited as a thin red film.

Mustard.—The microscopic characters of mustard-seed are very distinctive, and the presence of adulterating ingredients can therefore be very readily made out, the more so as it contains no starch. There exist in mustard a number of very well-defined compounds, some of which contain sulphur. An estimation of the total quantity of sulphur present in a sample can be made an approximate measure of the actual quantity of pure mustard in it, as can also a determination of the percentage of *oil*, the common

adulterants of mustard containing neither of these substances in more than very small amount. The most common adulterations of mustard are wheat-flour and turmeric. The microscope at once reveals their presence and an approximation to the true percentages can be made by comparing the sample under examination with standard samples made up of pure mustard with varying quantities of the adulterants. By treating mustard thus adulterated with iodine the blue colour which the latter strikes with starch shows the presence of flour, and caustic potash solution added to mustard containing turmeric, reveals the presence of the latter by a bright red colouration of the turmeric specks. From the hygienic point of view there can be no doubt that the use of *pure* mustard with food is not desirable, and that the addition of a little starch is an advantage.

Plaster of Paris, chromate of potash (a yellow substance), clay, and gamboge, are all stated to have been found in mustard. Special tests must be made for these substances should the microscope or the percentage of ash give rise to suspicion. There is no doubt of the occasional use of gamboge, although it is rare, and it is certainly a most objectionable adulterant.

A percentage of ash higher than 5 would show mineral, and lower than 4 organic adulteration, the average ash of mustard being 5 per cent.

Pepper.—Unlike mustard, pepper contains starch, the granules being very small. It is found adulterated with ground rice, wheat-flour, linseed, and mustard-husk, and with sand. These are the only common adulterations; although some observers give a formidable list of the substances used. The determination of the ash, which varies from 1·5 to 5 or 6 per cent., and should never exceed 7 per cent., detects mineral impurities such as sand. The microscope shows the presence of ground-rice, this being indeed the commonest adulterant.

Condensed, Prepared, and Preserved Foods.—The very large number and variety of such articles renders it impossible to

do more than allude to them as substances which come under the notice of the analyst in increasing number. Some of the cheaper tinned foods are occasionally deleterious, either through imperfect preparation and consequent decomposition, with accompaniment of fungoid growths, or from the action of the foods themselves on the metal of the containing vessel s; but the extremely rare occurrence of cases of poisoning does not warrant the scare which seems to exist with regard to them.

Examination of Soils.—The complete analysis of a soil is a very long and tedious process. It will be enough to indicate that for the purposes of the hygienist the determination of the percentage of water contained, of the power of holding water, of the amount of loss and behaviour on incineration, together with a microscopic examination, is as much as is generally required for practical purposes.

Arsenical Wall-papers and Pigments.—These are now well recognised as fruitful causes of disease. There are several methods of detecting arsenic, one of the best being Marsh's, which has already been described.

Disinfectants.—The principle of the method usually employed to judge of the value of a particular disinfectant consists in comparing its preserving power in solutions of different strengths with that possessed by some standard disinfectant, such as carbolic acid. Milk or meat is perhaps the most convenient substance for such experiments. Equal volumes or weights are treated with measured volumes of the disinfectant solutions, and are examined daily by the microscope, and otherwise, for the signs of decomposition.

The foregoing sketch of hygienic analysis is necessarily very limited, but enough has been said to show the general nature of the plans employed, more particular attention having been paid to common adulteration and impurity, rather than to the processes used in the investigation of food-substances for purely scientific purposes. But it must not be supposed that the list of articles which find their way to the hygienic laboratory is by any means

exhausted. The examination of articles of clothing and decoration, of the innumerable substances used as deodorisers and disinfectants, of soils and of drugs, opens up, as will readily be seen, an extremely wide field of work.

INTERNATIONAL HEALTH EXHIBITION.

HYGIENIC LABORATORY.

(*Annexe to City and Guilds Institute.*)

Director—PROFESSOR CORFIELD, M.A., M.D. (Oxon), F.R.C.P.
Chief Assistant and Demonstrator—MR. CHARLES E. CASSAL, F.I.C., F.C.S.
Assistant—DR. W. FRASER, San. Sci. Cert., Cambridge.

THIS Laboratory is designed to show, as far as is possible in a temporary building, the arrangements suitable for the examination, from a Public Health point of view, of water, air, foods and drinks, soils, disinfectants, sanitary appliances, and other articles of Hygienic interest. In front of the Laboratory proper is an ante-room in which are arranged cases of apparatus of various kinds for exhibition and use in the Laboratory, and also a model laboratory table.

Projecting into the ante-room and entered from the Laboratory is the balance room, which should be separate from the Laboratory, but is here merely a glazed compartment, so that the operations conducted in it may be visible to the visitors; the balances, lent by Mr. Oertling, are supported on a pier with a solid foundation of masonry to prevent vibration; most of these instruments are very delicate, being capable of weighing to the one-thousandth part of a grain with comparatively heavy loads on the pans.

On each side of the balance room, in the ante-room, is a table on which are placed microscopes with various specimens for examination.

In the body of the Laboratory are placed three working-tables with bottle-racks above them, and drawers and cupboards for apparatus underneath; and around the sides, tables for microscopic work and distillations, with shelves for apparatus and bottles containing reagents, a furnace with sand bath on the top for evaporating purposes, and two glazed draught cupboards in which operations producing fumes may be conducted; these cupboards are provided with flues in which jets of gas are burning in order to produce currents of air which convey the fumes outside the building; the laboratory tables are provided with appliances for the supply of gas and water, and with sinks, the waste pipes of which are connected with a stoneware drain discharging into an open trapped gully outside the Laboratory, and having an inspection opening, with a ventilating pipe carried above the eaves, at its upper end.

The operations conducted in the Laboratory are sufficiently described in the handbook entitled "Public Health Laboratory Work," and consist chiefly in the examination by chemical, microscopical and other means, of specimens of water and air with the view of determining the nature and amount of various pollutions, and the analysis of articles of food and drinks to ascertain their quality and to detect the presence and estimate the quantity of impurities and adulterations, also the examination of filtering materials and of disinfectants, and the detection and estimation of poisonous ingredients, such as arsenic, in the colouring matters used for decorative purposes, clothing, &c.

Specimens of accurately graduated flasks, burettes, thermometers and other apparatus used in the operations conducted in the Laboratory may be seen in the cases and on the tables, and also in actual use.

LONDON WATER SUPPLY.

BY

COLONEL SIR FRANCIS BOLTON, C.E.

WATER EXAMINER "METROPOLIS WATER ACT, 1871."

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PREFATORY NOTICE.

THE Author desires to express his cordial acknowledgments to the Engineers and Secretaries of the Metropolitan Water Companies for their important contributions in aid of the compilation of this book, and also to another member of the Sub-Committee, appointed in connection with the London Water Supply Exhibit at the International Health Exhibition, 1884, his friend Mr. Philip A. Scratchley, M.A., Oxon, for invaluable assistance in digesting, arranging, and revising the whole of the matter for press.

The Maps which appear in these pages were prepared from information kindly furnished by the Engineers.

The Author ventures to hope that this publication will be found of use in meeting an existing want, viz., a treatise on the System of the Metropolitan Water Supply; a subject of which the vast majority of water-consumers (in other words, of the public at large) have but little knowledge.

The following pages are designed to give a concise description of How London is supplied with

Water; the modes of collection, storage, and distribution; the rates authorized to be levied; the History and Description of the Water Companies, their financial and legal position, and how they are controlled; together with suggestions respecting water-fittings in houses, and the official Regulations concerning the same. In short, the work is intended to convey information useful as well to Shareholders in the Water Companies as to Householders generally, and to serve as a text-book on the subject of London Water Supply, or (if the term be not too ambitious) as a Water-Consumers' *Vade Mecum*.

In a publication abounding, as this does, in figures and statistics, errors are specially apt to creep in, notwithstanding that the greatest care has been exercised to secure strict accuracy. Should any mistakes, therefore, be met with, the Author trusts they will be regarded with a lenient eye, and he will be greatly obliged by their being pointed out to him.

4, *The Sanctuary, Westminster*,
1884.

LONDON WATER SUPPLY.

PART I.

GENERAL INTRODUCTION.

CHAPTER I.—NOTES ON WATER SUPPLY.

1. Sources of Supply.—The sources whence a supply of water suitable to the requirements of a town or district may be obtained, can be classed generally under the three following heads, viz.—(*a*) Rivers, (*b*) Lakes, and (*c*) Wells. As water is one of the chief necessaries of life, every town, however small, must have some water supply; and the position and size of the town will probably not leave much choice in the selection of the source from which this supply is to be taken; but should any alternative exist, it is only by a careful consideration and comparison of the quality and quantity to be derived from the sources available, as well as of the expense of distributing the supply from each, that a satisfactory conclusion can be arrived at.

(*a*) *Rivers.*—This source may be taken to include all running waters, such as springs, streams, &c.

The ordinary flow of rivers is due to springs or other underground drainage, and it is only in times of flood or constant rain that surface waters find their way into the channel. In many rivers the fall is sufficiently great to enable the supply to be obtained by gravitation, by going some distance above the town. When this is not the case, pumping stations have generally to be provided. At the same time the character of most rivers will generally

require some means to be adopted for the purification of the water.

(*b*) *Lakes.*—Under this head are included artificial reservoirs as well as natural lakes. Both are fed by streams, or by those porous soils which, acting like a sponge, serve to retain the rain until it is drained out by channels cut through them. In hilly districts the daily flow of small streams, fed chiefly by rains, is seldom sufficient for any large supply. It is therefore usual to store the water falling during the rainy season in large reservoirs, formed by throwing a dam of earthwork or masonry across a valley, thus constituting a large artificial lake.

If the gathering ground is favourable, and free from cultivation and animal contamination, water of great purity and extreme softness is obtained.

(*c*) *Wells* constitute the remaining source of supply, by sinking which water is obtained from the water-bearing strata below the surface. It need scarcely be said that well-water varies very much in quality, containing generally a large proportion of the various salts existing in the strata from which it is drawn. Many wells yield large supplies, 2,000,000 gallons per diem being not uncommon. In some wells the water rises above the surface, as at Bourne, in Lincolnshire, where there is a well 92 feet deep, yielding 567,000 gallons a day at an elevation of 39 ft. 9 in. above the ground, thus supplying the town by natural pressure. (See *Transactions, Inst. C. E., vol. lxxv.*)

2. Modes of Purification.—Except from mountain streams, springs, and some wells and gathering grounds, water is seldom found of sufficient purity to be distributed for general consumption without some means of purification. These may generally be divided into mechanical and chemical. The usual mechanical process is filtration, by which water is allowed to slowly percolate through sand, or other porous material, the surfaces of which arrest the particles of dirt, &c., held in suspension by the water. In

case the water is discoloured, or contains much organic impurity, this mechanical process is usually supplemented by a chemical one, such as Spencer's process, in which spathose iron ore is used, or Bischoff's, where spongy iron is employed; or if the body of water to be dealt with is small, then it may be purified by filtering through charcoal, or other suitable porous material. Hard water, where the hardness is due to the presence of carbonate of lime, may be softened by the process invented by Dr. Clark, which has been adopted to a considerable extent.

3. MODES OF DISTRIBUTION.—When the source of supply is at sufficient altitude, the water is led through an aqueduct to the town, where by means of branch pipes it is delivered into the houses for consumption. Where, however, the source is not thus favourably situated, it is necessary to raise the water to a sufficient elevation by means of pumps. These generally pump into service reservoirs close to the town, the water thence descending by its own gravity. Where no site is available for service reservoirs, it is necessary to pump directly into the houses. This entails a large excess of pumping power and extra mains, so that it is only adopted where there is no alternative. The service reservoirs, unless situated in a very pure atmosphere, should be covered. Indeed, this plan is always advisable, as the water is thereby not only preserved from the impurities of the atmosphere, but is protected from the frost of winter, and the heating and vivifying effects of the sun's rays in summer.

4. MODES OF SUPPLY.—The modes of supply may be broadly divided into "intermittent" and "constant," the former when the water is turned on at intervals for a short time, and the latter when the mains are always charged.

The advantages of the constant system are generally admitted. The water is delivered through the pipes direct from the reservoirs to the consumer; whereas, by the intermittent mode, the water must be stored in cisterns, where it is in many cases exposed to contamination from the atmosphere, and from the decay of any organic substance that may find its way into such receptacles.

5. Average Consumption.—The quantity of water per head to be supplied to a town can only be determined by experience. The following table, prepared from figures given by Sir J. W. Bazalgette, C.B., shows the great difference that exists in the quantity of water supplied to different towns.

Table Showing Consumption of Water per Head of Population.

	Gallons per Head.		Gallons per Head.		Gallons per Head.
Alexandria	18–20	Genoa	24½–97¾	Pietermaritzburg	44
Amsterdam	11·15	Hague	17·6	Riga	31·1
Adelaide	50	Hamburg	45½	Rio	30
Athens	21·56	Hanover	15·09	Rome	160·38
Baltimore	54	Hong Kong	5–18	Rotterdam	22·45
Barcelona	7–14	Kurrachee	25	Rouen	30·8
Berlin	13·3	Lahore	10	San Francisco	64½
Bombay	20	Lausanne	126	St. Petersburg	21·3
Boston	73·3	Liége	16½–30	Sanjago	5·6
Brisbane	33⅓	London	31¼	Seville	7·26
Buenos Ayres	20	Madrid	3·3	Stockholm	13½
Buda	12½	Marseilles	158·4	Stuttgart	26·4
Cairo	11	Montreal	60	Sydney	25
Calcutta	22	Munich	33	Toronto	82
Chicago	102½	Naples	15·4	Trieste	4·4
Christiania	39·7	New York	60·9	Valparaiso	20
Copenhagen	13·9	Ottawa	102½	Venice	8
Delhi	16	Paris	36	Vienna	13·20–19·8
Dresden	14·96	Pernambuco	7·3	Washington	143
Durban	2	Pest	33		
Frankfort	24	Philadelphia	54·15		

The quantity likely to be required for domestic purposes in any district is governed more by the facility with which the water can be disposed of after use than by any other consideration. In a town that is well drained, and contains houses fitted with baths and other conveniences, the consumption is only kept within bounds by the cost where water is sold by meter, and by special regulations strictly enforced on the consumer where it is sold according to the rateable value of the house supplied. The quantity required by manufacturers can be separately estimated.

An excess of water in a town provided with cesspools instead of drains is likely to prove injurious, as the water in passing through the cesspits is liable to saturate the surrounding soil with sewage, thus causing, by evaporation, a pestilential atmosphere.

6. MODES OF CHARGING CONSUMERS.—Considerable difference of opinion exists as to the most equitable mode of charging consumers for water supplied for domestic purposes. Water is sometimes sold by measure, but generally speaking payment is taken by a rate upon the annual value of the premises supplied. By the latter mode, the use of water is not restricted by any motives of economy; and the rates charged to houses of the better class admit of water being supplied to dwellings of the poorer class at a rate below that which would otherwise be possible. It cannot be denied, however, that under this system a considerable proportion of the water supplied to the consumer is wasted. Waste of water is the cause of additional outlay, not only in the construction of works, but in working expenses, and such additional outlay naturally entails a higher charge for the water than would otherwise be necessary. The meter system has no doubt some advantages, but there is a drawback to its use for domestic supply, which must not be overlooked, namely, the cost of providing and keeping the meters in repair, and the expense of the necessary inspection. The interest on the first cost, together with the expense of repairs and inspection, must fall on the consumers, and add to the charges they have to pay. It is possible that these considerations may have prevented the adoption of the meter system for general domestic purposes in some of our largest provincial towns, where the water supply is in the hands of the ratepayers.

7. DUAL SUPPLY.—In the case of many large towns an abundant supply of water of inferior quality is found in close proximity, while further off, but still within reasonable distance, a limited supply of better water exists, and it sometimes becomes a question whether both sources of

supply should not be adopted, the latter for drinking purposes, and the former for domestic and manufacturing uses. In the opinion of the writer, a system of dual supply is not practicable for domestic purposes alone, but only where municipal or manufacturing requirements have to be provided for as well.

When only one supply exists for domestic purposes, means are generally taken to render it as pure as possible, either by efficient filtration or by such other means as may be found necessary. A separate supply for municipal purposes can be used for road watering, sewer flushing, fires, &c., without affecting the domestic supply. In most manufacturing towns the factories are grouped together, and require large quantities of water at a cheap rate, which can often be supplied from sources sufficiently pure for purposes of manufacture, although it may be unfitted for household consumption.

A dual supply for domestic purposes would entail a considerable extra outlay on the construction of works, as a double line of mains would be necessary in every street, and the cost of most of the house fittings would be doubled, as they would have to be in duplicate. Another objection is the probability that the excellent quality of the water supplied for potable purposes would cause the quality of the other to be little considered, and the latter might be allowed to deteriorate, or become subject to contamination. Consumers, bearing this in mind, would probably use the purer water almost entirely. In ordinary times, this might not be of much consequence, but in times of drought it might be serious.

In connection with this subject, it may be mentioned as an interesting fact that when the Chelsea Water Company first moved their intake to Ditton a separate reservoir was constructed, and extra mains were laid for supplying unfiltered water for road watering and other purposes, but in practice this arrangement was found to be no saving, so it was discontinued, and now none but filtered water is supplied.

Where water pressure is required for power, it is advisable to have a separate system, as the pressure needed for its economical application is so much greater than that necessary for domestic supply. A moderately hard water is generally preferred for drinking, while for all cleansing and most manufacturing purposes soft water is considered better. In supplying a town, however, the health of the inhabitants should be the first consideration.

CHAPTER II.—WATER FILTRATION.

THE purity of a domestic water supply is undoubtedly a matter of the utmost importance, but what *is* pure water is a question which, in the absence of any recognised standard of purity, does not at present admit of any precise definition, inasmuch as different authorities on the subject hold different, and in some respects contradictory, theories regarding it. This much, however, is admitted—that efficient filtration is in most cases essential to purity.

When the supply of water is taken, as it is in the metropolis, from public waterworks, as much as possible is generally speaking done to ensure that the water as it leaves the reservoirs of the companies shall be perfectly fit for drinking. In the great majority of cases, unfortunately, before the water reaches the consumer, it has to pass through what has been, perhaps not too harshly, styled that domestic abomination—the water cistern, where the purest water is often liable to contamination from the dirty and neglected state of the cistern itself. The radical remedy for this state of things would be the universal adoption of the system of "constant supply." This, however, is still a question of the future, and consequently the use of filters is likely to continue to be general. It is obviously of great importance, where filters are used, that care should be taken to secure their continued efficiency, which is to a certain extent impaired by every drop of water that passes through them. Filters cannot be relied on for an indefinite period. After a while they become foul and inert.

There is therefore a point at which all filters not only

cease to be efficient purifiers of water, but may themselves impart contamination. The length of time during which a filter will continue to work properly obviously depends, to a very great extent, upon the quality of the water passed through it. Water containing a large amount of contaminating matter must clog it up, and exhaust its oxidizing capabilities much faster than water which contains very little. If the house cistern from which the supply is drawn is kept clean, the water will require less filtering, and the filter will last all the longer. Comparing great things with small, the practice of the London Water Companies may be cited, who allow their supply to stand for some time in "subsidence reservoirs," in which much of the suspended matter gradually settles to the bottom, and from which the water is quietly drawn off for filtration, thus easing the work which the filter-beds have to do. Similarly, much may be done by a little care to prolong the efficiency of the domestic filter. The removal at intervals of the surface of the filtering material will also restore much of its capability of usefulness, since it is just the external coating that intercepts most of the solid matter the water may contain.

The process of filtration may be said to be both chemical and mechanical, especially in the case of large filter-beds, for a process of chemical decomposition goes on simultaneously with the merely mechanical process of straining. Decaying organic substances poured with the water into a filter-bed, are not merely arrested, but are rapidly decomposed and resolved into their elementary constituents, which again are promptly recombined in other forms. This chemical change is scientifically explained by the theory that every particle of sand is closely enveloped in a film of condensed air, and that the particles of organic matter being thus brought into close contact with a body of oxygen, undergo rapid decomposition. It is well known that all solid bodies attract about them an atmospheric film, and, therefore, as a bed of sand and gravel is an agglomeration of minute stones, each with its

coating of compressed air (or, in other words, compressed oxygen and nitrogen), the water filtering through the interstices has to pass through a concentrated body of oxygen capable of rapidly decomposing it, and forming other compounds. Consequently, if we take the case of a decayed leaf, for example, we can see that it would be resolved to some extent into carbon, nitrogen, and hydrogen, which, recombining with the oxygen, form carbonic acid gas, ammonia, and water. As the result of this chemical process the polluting vegetable matter will have actually vanished, and though the filter-bed has really abstracted it from the percolating water, the bed itself will show no trace of it. Following out this theory, it has been asserted by chemists that when some of the London Companies drew their supplies from the tidal portion of the Thames where it received all the sewage of London, their filter-beds did not clog up nearly so fast as might have been expected. Scientific experiments showed that the filter-beds must have intercepted considerably more impurity than was actually found in them, and the phenomenon was explained by the theory that filtering was not merely a mechanical straining process, but one also of rapid chemical action, by which the polluting matter intercepted was destroyed and converted by oxidation.

The filter-beds of the London Companies consist of sand, gravel, &c. arranged in layers of varying thickness, and it is manifest that a considerable quantity of solid impurity must be removed from water by the merely mechanical process of straining through this porous mass. The polluting matter is arrested, to a great extent, by the sand and gravel, which, of course, after a while get choked up, becoming not merely less pervious to water, but also sources of contamination. It is consequently the practice of the Companies to remove the surface of the sand at frequent intervals, and periodically to renew the filter-beds entirely. But, curiously enough, it has been proved by careful scientific observation, that the filtering medium does not, as a matter of fact, become so rapidly clogged up as might be expected,

judging by the amount of extraneous matter actually abstracted from the water. For the sake of illustration, let it be granted that a hundredweight of impure matter will in theory entirely destroy the filtering efficiency of a given quantity of sand, yet the latter will in reality abstract from the water passing through it more than a hundredweight of impure matter without wholly losing its filtering efficiency. In other words, a considerable proportion of the intercepted matter is oxidized, and the filter will be found upon examination to contain less contaminating substance than it can be proved to have intercepted from the water passed through it. This is only explainable by the theory of chemical change described above. A similar process goes on in the small domestic filter in which, instead of several feet of boulders, gravel, shells, and sand, there are only a few inches of some porous substance, presenting a certain amount of surface for the air to cling to and for the water to pass over.

From what has been said, it will be seen that there are two reasons why a filter must not be relied upon indefinitely for the purification of water. In the first place, it is gradually choked up by the pollution it is continually abstracting from the water passing through it, and in the next the air coating upon which the chemical action depends becomes exhausted, and the oxidizing process gradually ceases. The Water Companies are frequently blamed for delivering unpotable water, when if the true delinquent were sought it would be found to be the water consumer himself, whose lack of attention to his cisterns and filters has created the evil of which he complains.

SYSTEM OF THE LONDON WATER SUPPLY.

CHAPTER III.—HOW LONDON IS SUPPLIED.

1. *Preliminary Remarks.*

It is not altogether easy to realise the magnitude of the operations by which London is supplied with water. Nearly five millions of human beings have to be provided with that which is essential to their health and comfort, and the supply must never fail. In the following pages will be found a description of the plans adopted for this purpose, together with a history of the various Companies, tracing their gradual development from the commencement down to the present time. From the particulars given it will be seen that the existing supply may be regarded as satisfactory in most points, though many improvements could be introduced with advantage both to the consumers and the Companies: to the Companies by the prevention of the great waste that undoubtedly takes place, and to the consumers by the introduction of a constant supply direct from the mains, without the intervention of the contaminating cisterns at present so largely in use. The system of payment for water on the annual value of the house supplied has been and is the cause of considerable controversy, as are also the additional charges which the Companies are authorized to make for baths, high service, and other extras. With each re-valuation of property there is in some districts an increase in the

rateable value, and it is a popular complaint that the Companies have the right to raise their charges without being obliged to give any equivalent benefit to the consumer. On the other hand, it is only fair to bear in mind that where the value of house property in any part of London declines, the Companies are compelled to take a reduced payment while rendering the same service as before; and they point out, moreover, that the parishes are constantly increasing the rateable value of the Companies' property.

The distribution of water under eight different Companies is not conducive to economy of management, and many improvements could undoubtedly be effected, with a saving of cost, if all were brought under one central authority. On reference to the Map (facing p. 499, *infra*) showing the districts over which each Company has the right of supply, it will be seen that nearly all the parishes are supplied in part by two, and many by more than two, Companies; each Company arranging with its neighbour a boundary line to govern the limits of the supply.

The Companies contend, with some reason, that if they were compelled to alter their mode of charge it would be a breach of faith on the part of Parliament, and would subvert the fundamental basis on which the shareholders subscribed their money. The acquisition of the Companies' undertakings by a central authority to be constituted for the purpose is a subject that has already engaged the serious attention of Parliament. It is to be hoped that, should such a transfer ever take place, these undertakings may be secured on reasonable terms, and that such arrangements as to charge will then be made as will meet the ideas of the day.

2. *Whence London is supplied.*

The water supply of London is drawn from the Rivers Thames and Lee, and from certain springs and under-

ground sources in the valleys of those rivers, including Chadwell Spring, and eighteen wells sunk into the chalk, of which eight are in the north of London and ten in the south.

Early in 1884, the proportions taken from these several sources of supply were nearly as follows:—

From the Thames and certain chalk springs in the Thames Valley, about	50 parts of the whole
From the Lee and certain chalk springs in the Lee Valley, about	38 parts of the whole
From the 18 chalk-wells about .	12 „

In 1866 the proportions were 49 parts from the first group, 44 from the second, and only 7 from the chalk springs. It thus appears that the river supply forms a smaller proportion of the entire quantity now than formerly, while the proportion taken from the chalk wells is nearly doubled.

3. *By whom London is supplied, and under what control.*

London is supplied by eight Water Companies, which are controlled in common by certain general enactments, the Metropolis Water Acts of 1852 and 1871, and provisions in the Fire Brigade Act of 1865, also the Waterworks Clauses Act of 1847, which is expressly applied to them. But, subject to these general enactments, they are governed by their own special Acts, each Company having an independent area, a separate system of pipes, and peculiar regulations suitable to its own circumstances. The object of the Act of 1871, as specified in its preamble, was to make further provision for securing to the metropolis, and to certain places in the neighbourhood thereof, a constant supply of pure and wholesome water. Section 3 of the Act defines the term "Company" as meaning

and including "The Governor and Company of the New River brought from Chadwell and Amwell to London, commonly called 'The New River Company;' The East London Waterworks; The Southwark and Vauxhall Water Company; The Company of Proprietors of the West Middlesex Waterworks Company; The Company of Proprietors of Lambeth Waterworks; The Governor and Company of Chelsea Waterworks; The Grand Junction Waterworks Company; The Company of Proprietors of the Kent Waterworks; and also any other corporation, company, board, commissioners, association, person, persons, or partnership, for the time being supplying water for domestic use within the limits of this Act."

4. *Sources whence each Company draws its Supply.*

The eight Water Companies are authorized to obtain their supply in the manner following:—

1. Kent Waterworks Company, from the Chalk wells between Crayford and Deptford.
2. New River Company, from the River Lee, and wells at Amwell End, Amwell Hill, Hoddesdon, Turnford, Cheshunt, Southgate, and Betstile and Broad Mead. The total volume which may be taken daily is unlimited.
3. East London Company, from the River Lee, from which the quantity that may be abstracted daily is unlimited; from deep wells in the chalk at Walthamstow and Chingford; and from the Thames at Sunbury, the volume to be abstracted daily at that place being limited to 10,000,000 gallons.
4. Southwark and Vauxhall Company, from the Thames at Hampton.
5. West Middlesex Company, from the Thames at Hampton.
6. Grand Junction Company, from the Thames and gravel beds at Hampton.

7. Lambeth Company, from the Thames at Molesey, and springs from the gravel beds and chalk at West Molesey and Ditton.
8. Chelsea Company, from the Thames at Molesey.

The volume which may be taken daily from the Thames is limited to 20,000,000 gallons for each of the Thames Companies, and 10,000,000 for the East London, making together 110,000,000 gallons, but from the other above-mentioned sources the volume is unlimited.

5. *Amount expended by the Companies.*

As shown in the tabular Statement subjoined, the total certified expenditure of the Companies to December 31, 1883, amounted to £13,150,318. Subsequent to the passing of the Act of 1871, the Water Companies have, of their own accord, and in consequence of recommendations from the Metropolitan Water Examiner appointed under the Act, incurred and undertaken a considerable expenditure, amounting altogether to £3,175,320, for the improvement of the water supply both in quantity and quality, by extending the storage capacity of their reservoirs, and increasing their areas of filtration, as well as by providing for the requirements of constant supply, by the construction of high-service reservoirs for filtered water, the laying of mains, and the addition of powerful machinery to their works.

STATEMENT OF CERTIFIED EXPENDITURE OF THE EIGHT METROPOLITAN WATER COMPANIES ON WORKS, IMPROVEMENTS, &C., TO 31ST DECEMBER, 1883.*

Name of Company.	Total Certified Expenditure to 31st December, 1883.		
	£	*s.*	*d.*
1. Kent	663,288	9	9 †
2. New River	3,321,100	7	5
3. East London	2,156,176	6	0
4. Southwark and Vauxhall	1,807,104	12	9
5. West Middlesex	1,159,312	15	4
6. Grand Junction	1,369,497	14	3
7. Lambeth	1,518,858	13	1
8. Chelsea	1,154,979	10	11
Total	13,150,318	9	6

* It will be observed that the *Tables* 1A to 8A (*infra*), having been compiled for the International Health Exhibition, 1884, *prior* to the issue of the above Official Statement, only contain the Expenditure up to the 31st of December, 1882, in the case of the Kent, New River, and East London Companies, and up to the 31st of March, 1883, in the case of the remaining five.

† To the above total £663,288 9*s.* 9*d.*, has to be added the sum of £75,284 18*s.* 9*d.*, being the "Difference between the nominal value and the sums realised on the issue of Shares between 1809-58, confirmed and allowed, Kent Waterworks Act, 1862," thus making the total of £738,573 8*s.* 6*d.* shown in the Company's audited Accounts to the 31st of December, 1883.

CHAPTER IV.—THE METROPOLITAN WATER EXAMINER.

1. *His Duties.*

AMONGST the important provisions made by the Metropolis Water Act, 1871, in the interests of the consumers, was one which required the appointment of a Water Examiner, "being a competent and impartial person," who should from time to time examine the water supplied by any Company, in order to ascertain whether or not the Company had complied with the requirements of section 4 of the Metropolis Water Act of 1852, which enacts that "every Company shall effectually filter all water supplied by them within the Metropolis for domestic use, before the same shall pass into the pipes for distribution."

The effectual filtration of river water depends upon—

1stly. A sufficient area of properly constructed filter-beds, constantly cleaned and fresh sanded from time to time as the original thickness is reduced:

2ndly. The rate of filtration being controlled, and limited to a certain speed:

3rdly. The water delivered into the filter-beds having been previously stored in subsiding reservoirs, and the capacity of these reservoirs being such as to avoid the necessity for the intake of turbid and muddy water during the time of extraordinary and heavy floods, which tend to foul and choke the filters.

2. *Information given in his Reports.*

In addition to inspecting the filter-beds and reservoirs, and examining the quality of the water both at the intakes

and after filtration at the works, the Water Examiner includes in his examination reports, which are published monthly and annually, the following information respecting each of the Metropolitan Water Companies :—

1. Source of supply.
2. Situation of the works.
3. Total volume which may be supplied daily, in gallons.
4. Average daily supply during each month, in gallons.
5. Estimated percentage delivered for other than domestic purposes.
6. Number of houses supplied.
7. Number of houses on constant supply.
8. Estimated population supplied within the districts of the Water Companies.
9. Number of subsiding and storage reservoirs for unfiltered water, showing the area in acres, and available capacity in gallons.
10. Number and capacity of the storage reservoirs for filtered water (covered within the radius prescribed).
11. Engine power, and horse power thereof.
12. Number of miles of mains in each district.
13. Number of miles of mains in the Metropolis.
14. Number of miles of streets with mains constantly charged, within the Metropolis.
15. Number of street hydrants and private fire-cocks erected within the Metropolis, and number of fire-plugs.
16. Greatest lift by steam power.
17. Greatest and least head of pressure in the district supplied.
18. Number of filter-beds, with area in acres.
19. Depth of sand and other materials composing filter-beds.
20. Maximum rate of filtration per square foot of filtering area, in gallons per hour.
21. Number of acres of filter-beds cleaned during each month.

22. Appearance of water before and after filtration.
23. Condition of samples taken daily.
24. Statement as to progress of works and alterations made by each Company, and of works proposed and recommended to be undertaken.
25. Analysis made by Dr. Frankland, F.R.S., of the water supplied to the Metropolis and other places.
26. Analysis of the water supplied to the Metropolis, made for the Companies by analysts of their own appointment.
27. Report made for the Metropolitan vestries by other chemists, on the organic matter in the water supplied to the Metropolis.

3. *Rate of Filtration in Theory and Practice.*

The water in the Thames and Lee during the winter months is frequently very turbid, and when in that condition is extremely difficult to deal with. The solid impurities in suspension are only practically got rid of by long subsidence previous to filtration, as they chiefly consist of clay, marl, and chalk in a very finely divided state; but the companies, being generally provided with sufficient storage reservoirs, are nearly always enabled to allow the turbid water to flow by, and only take in water when the rivers are at their best.

The rate of filtration of the Metropolitan water supply should not exceed 540 gallons per square yard of filter-bed each 24 hours, or $2\frac{1}{2}$ gallons per square foot per hour. Filtration ought to be effectual at this rate, which for all practical purposes may be considered as a standard. Effectual filtration is greatly facilitated by previous subsidence.

The average rate of filtration per square foot of filtering area per hour for each of the seven river Companies is as follows:— New River, $1\frac{1}{2}$; East London, $1\frac{1}{3}$; Southwark, $1\frac{1}{2}$; West Middlesex, $1\frac{2}{3}$; Grand Junction, $1\frac{3}{4}$; Lambeth, $2\frac{1}{8}$; and Chelsea, $1\frac{3}{4}$. No Company, therefore, now exceeds the desired rate of filtration.

4. *Matters to which Householders' attention should be given.*

The water as delivered by the Companies to their respective districts is, generally speaking, good in quality and effectually filtered, but it is frequently allowed to deteriorate after reaching the cistern of the consumer. The subject has already been adverted to in the chapter on Water Filtration (*ante*, p. 474). As there pointed out, the radical remedy for this lamentable state of things is undoubtedly a constant supply; but until such constant supply is general, the attention of all householders should be given to the fittings and cleanliness of their cisterns, as well as to their house drains, and the water pipes connected therewith. These are matters upon which depend in a great measure the purity and abundance of the domestic water supply.

The exercise of Government supervision tends to the effectual filtration and delivery of good water by the Companies to their respective districts; but an inspection of the cisterns in houses too frequently shows that they are in a state of foulness, which is generally attributable to neglect.

The attention of householders should also be given to the following points:—

1. All stop-valves should be fixed outside their premises. If the stop-valve is inside, then in the event of a severe frost, and a number of bursts occurring on the lead communication pipes, all the houses in the street are deprived of their supply during the whole time that the repairs are being effected on the burst pipes, whereas if the stop-valve is outside, it will only be necessary to shut it down.

2. Clause 14 of the Board of Trade Regulations, 1872, relating to waste pipes (see Appendix I., p. 678, *infra*), should be carried out in its integrity.

Contamination of water from gases generated by sewage is of far more frequent occurrence than is generally understood. Waste pipes from cisterns are still to be found

which are in direct communication with drains, so that gases may flow back into the cisterns and become absorbed by the water. To prevent this an overflow pipe should be brought outside each house and the end left exposed to the air, instead of being carried into a drain, as is often the case. By the adoption of this plan the poisonous effluvia and gases from drains will be got rid of, which would otherwise ascend through the pipe, and not only be partly absorbed by the water in the cistern, but be partly mixed with the air in the house, thereby becoming a cause of fever and disease.

3. In houses supplied on the Constant System, all danger of drinking stale or contaminated water from cisterns may easily be avoided by attaching a small Draw-off Tap to the communication-pipe which supplies the cistern from the main in the street. Water may then be drawn at any moment, day or night, direct from the main.

5. *Rules to be observed in adopting Constant Supply.*

The Water Companies are gradually extending the system of Constant Supply in their respective districts. It would materially facilitate its general introduction if the following rules, based upon the Regulations as to fittings confirmed by the Board of Trade,* as provided in the Metropolis Water Act, 1871, were observed by water tenants in effecting the change from intermittent to constant supply, viz. :—

1. *Communication Pipes.*—Point of entry must be first approved by the company. Pipe to boundary fence should be new, or where the Company allow the existing lead communication pipes to remain, the strength and soundness will be entirely at the risk of the consumer. Weight of pipes to be as specified in Regulation 2.

* For full text of these Regulations, with copy of Board of Trade minute confirming same, see Appendix I., *infra*, p. 674.

Iron pipes are not allowed if they are to be in contact with the ground.

Every house must have but one communication pipe.

Every house at present "branched," must have its own separate "communication pipe," except in the case of a group or block of houses (or those supplied by stand pipes) the water rates of which are paid by one owner; such owner may, at his option, have one sufficient communication pipe for such group or block.

The connection must be made by means of sound and suitable brass screwed ferrule or stop-cock, with union, and half-inch waterway.

The joints of the stop-cock and ferrule must be "wiped" by the consumer's plumber.

All joints must be of lead, and "wiped," or plumber's joints.

No pipe to be laid in or through drains or near gas pipes.

2. *Stop-valve.*—A sound and suitable screw-down stop-valve, not less than half-inch, and not greater than the pipe, must be fixed in the communication pipe at or near the entrance, and properly covered.

3. *Cisterns and Ball Valves.*—All cisterns must be above ground, properly covered, accessible for inspection and cleaning, and fitted with efficient ball-valves.

Wherever there is a wash-out pipe with ground plug, or any other kind of attachment, it must be connected to a warning-pipe.

4. *Standpipes.*—Standpipes or small cisterns, properly fitted, should be substituted for butts and underground cisterns.

Owners of small tenement houses are recommended, where practicable, to fix the standpipes in the kitchens or wash-houses, whereby they will be more protected from injury by frost or mischief, and future expense will be saved in repairs.

Standpipes must not be fixed over drains.

5. *Warning pipes.*—All waste-pipes must be removed or

converted into warning pipes, and so placed that the discharge of water may be readily seen by the officers of the Company. Such pipes to be of lead, and of the minimum weights specified in Regulation 29.

6. *Draw Taps.*—All draw taps must be sound and suitable, and of the "screw-down" kind.

Draw taps of the "screw-down" kind may be fixed on the rising main to supply water for drinking purposes.

Taps on the main over sinks ought to be of the "waste preventer" kind.

7. *Stand-Pipes in Courts.*—All stand-pipes or cocks fixed outside in courts or public places, to supply groups or blocks of houses, must be of the waste-preventer kind, and protected from injury by frost, theft, or mischief.

8. *Water-closets, &c.*—Water-closets, boilers, and urinals must be served through cisterns or service boxes, each water-closet, cistern, or service box to have an efficient waste-preventing apparatus, limiting the flush or discharge to two gallons of water, and urinals to one gallon.

Water-closet down pipes to be of dimensions and weight specified in Regulation 23.

9. *Baths.*—No bath to have any overflow pipe other than a warning-pipe. In every bath the outlet and inlet must be distinct and unconnected, the inlet to be above the highwater level, the outlet to have a water-tight plug, valve, or cock.

6. *Concerning the Extinction of Fires.*

None of the Companies are under any obligation to provide water sufficient for the extinction of fires; all that is required of them being to allow the gratuitous use of their water for this purpose, and to grant certain special facilities; such as keeping for inspection maps showing their pipeage and the spots where the screw-cocks are placed for regulating the service; and depositing keys of the fire-plugs at places prescribed by the Metropolitan

Board, so as to enable the firemen to act where they can without the Companies' turncocks. The fixing of fire-plugs was originally the duty of the parishes, but is now within the province of the Metropolitan Board, which can require the Companies to provide plugs at the Board's expense, but, as a matter of fact, the Companies provide them gratuitously. The value of Constant Supply for the purpose of fire extinction has been said with truth to be of even greater moment than its convenience to ordinary consumers.

CHAPTER V.—STATISTICS OF SUPPLY.

THE average daily supply of water furnished to the metropolis in 1883, for all purposes, was at the rate of 30.20 gallons per head of the population, and 226 gallons per house. This included the quantity used in the extinction of fires.

The number of houses returned shortly before the opening of the International Health Exhibition, 1884, as being under constant supply was 258,205, out of a total of 668,525.

A statement is appended showing the Unions supplied by the eight Metropolitan Water Companies, and also a List of the Districts supplied by each of them, and the names of the Parishes.

Accompanying this List is a map showing by colours the respective Districts actually supplied by the Companies as distinguished from their Limits of Supply under the various Acts of Parliament, which limits are also shown. The portions of the Districts under Constant Supply are marked, as are also those portions which are supplied by different Companies conjointly. The position of the respective Works of each company is indicated as well, the Pumping Stations, Reservoirs, and Filter-beds being each distinguished by particular marks.

The List of Districts is succeeded by eight Tables, which give full particulars relating to the Companies' Works, their sources of supply, situation, average daily quantity supplied by each, with the number of miles of mains, &c., as the same existed shortly before the opening of the International Health Exhibition of 1884.

The actual condition of these Works is described every month by the Water Examiner in his Reports, 250 copies of which are published and distributed regularly amongst the Water Companies, the Metropolitan Board of Works, the Vestries, the Medical Officers of Health, the London Press, and others interested in the subject of the London Water Supply.

THE FOLLOWING STATEMENT SHEWS THE UNIONS SUPPLIED BY THE EIGHT METROPOLITAN WATER COMPANIES.

Unions.	Area in Acres.	Sub-districts.	Name of Water Company giving Supply in the District.
West District.			
Kensington	3441	Kensington Town	West Middlesex.
		Brompton	Do. and Chelsea.
Fulham	4209	St. Peter's, Hammersmith	Do.
		St. Paul, Do.	Do. and Grand Junction.
		Fulham	Do. and Chelsea.
Paddington	1251	St. Mary, Paddington	Grand Junction and West Middlesex.
		St. John, Do.	Grand Junction.
Chelsea	861	Chelsea, South	Chelsea.
		Chelsea, North-west	Do.
		Chelsea, North-east	Do.
St. George's	2051	Hanover Square	Grand Junction.
		May Fair	Do.
		Belgravia	Chelsea.
Westminster	216	St. John, Westminster	Do.
		St. Margaret, Westminster	Do.
		Golden Square	Grand Junction.
		Berwick Street	New River and Grand Junction.
		St. Anne, Soho	New River.
North District.			
St. Marylebone	1506	All Souls, Marylebone	West Middlesex.
		Cavendish Square	Do.

STATEMENT SHEWING THE UNIONS SUPPLIED—*continued.*

Unions.	Area in Acres.	Sub-districts.	Name of Water Company giving Supply in the District.
North District—contd.			
St. Marylebone		Rectory, Marylebone	Grand Junction and West Middlesex.
		St. Mary, Do.	Do. Do.
		Christchurch, Marylebone	West Middlesex.
		St. John, Marylebone	Do.
Hampstead	2248	Hampstead	New River and West Middlesex.
St. Pancras	2672	Regent's Park, Pancras	West Middlesex.
		Tottenham Court	New River and West Middlesex.
		Gray's Inn Lane	New River.
		Somer's Town	Do.
		Camden Town	Do.
		Kentish Town	Do.
Islington	3107	Islington, West	Do.
		Do. East	Do.
Hackney	3935	Stoke Newington	Do.
		Stamford Hill	East London.
		West Hackney	New River.
		Hackney	East London and New River.
		South Hackney	East London.
Central District.			
St. Giles and St. George, Bloomsbury	245	St. George, Bloomsbury.	New River.
		St. Giles, South	Do.
		St. Giles, North	Do.

Strand	433	St. Martin-in-the-Fields	New River and Chelsea.
		St. Mary-le-Strand.	New River.
		St. Clement Danes.	Do.
Holborn	816	St. George-the-Martyr	Do.
		St. Andrew Eastern	Do.
		Saffron Hill	Do.
		St. James, Clerkenwell	Do.
		Amwell, Do.	Do.
		Pentonville	Do.
		Goswell Street	Do.
		Old Street	Do.
		City Road	Do.
		Whitecross Street	Do.
City of London	731	Finsbury	New River and East London.
		St. Botolph	New River.
		Cripplegate	Do.
		St. Sepulchre	Do.
		St. Bride	Do.
		Castle Baynard	Do.
		Christchurch	Do.
		Queenhithe	Do
		Allhallows Barking	Do.
		Broad Street	New River and East London.
East District.			
Shoreditch	648	Holywell, Shoreditch	New River.
		St. Leonard, Do.	Do.
		Hoxton New Town	Do.
		Hoxton Old Town	New River and East London.
		Haggerston	East London.

STATEMENT SHEWING THE UNIONS SUPPLIED—*continued.*

Unions.	Area in Acres.	Sub-districts.	Name of Water Company giving Supply in the District.
East District—contd.			
Bethnal Green.	755	Hackney Road	Do.
		Green, Bethnal Green	Do.
		Church, Do.	Do.
	405	Town, Do.	East London and New River.
Whitechapel		Spitalfields	East London.
		Mile End New Town	East London and New River.
		Whitechapel, North	East London.
		Whitechapel Church	Do.
		Goodman's Fields	New River and East London.
		Aldgate	New River.
St. George-in-the-East . .	244	St. Mary, St. George-in-the-E.	East London.
		St. Paul, Do.	Do.
		St. John, Do.	Do.
Stepney	569	Shadwell	East London and New River.
		Ratcliff	East London.
		Limehouse	Do.
Mile End Old Town . . .	679	Mile End Old Town, West	Do.
		Do. East	Do.
Poplar	2,648	Bow	Do.
		Bromley	Do.
		Poplar	Do.

South District.			
St. Saviour's, Southwark . .	1,170	Christchurch, Southwark	Lambeth and Southwark and Vauxhall.
		St. Saviour, Southwark	Southwark and Vauxhall.
		Kent Road	Southwark and Lambeth.
		Borough Road	Do. Do.
		London Road	Do. Do.
		Trinity, Newington	Do. Do.
		St. Peter, Walworth	Do. Do.
		St. Mary, Newington	Do. Do.
St. Olave's, Southwark . .	1,728	St. Olave, Southwark	Southwark and Vauxhall.
		St. John, Horselydown	Do. Do.
		Leather Market	Southwark and Vauxhall and Lambeth.
		St. Mary Magdalen	Southwark and Vauxhall.
		St. James, Bermondsey	Do. Do.
		Rotherhithe	Southwark and Vauxhall and Kent.
Lambeth	4,060	Waterloo Road, 1st	Lambeth and Southwark and Vauxhall.
		Do. 2nd	Do. Do. Do.
		Lambeth Church, 1st	Lambeth and Southwark and Vauxhall.
		Do. 2nd	Do. Do. Do.
		Kennington, 1st	Southwark and Vauxhall and Lambeth.
		Do. 2nd	Do. Do. Do.
		Brixton	Lambeth and Southwark and Vauxhall.
		Norwood	Lambeth.
Wandsworth and Clapham .	11,707	Clapham	Southwark and Vauxhall.
		Battersea	Do. Do.
		Wandsworth	Do. Do.
		Putney	Do. Do.
		Streatham	Lambeth.
Camberwell	4,450	Dulwich	Lambeth and Southwark and Vauxhall.

STATEMENT SHOWING THE UNIONS SUPPLIED—*continued*.

Unions.	Area in Acres.	Sub-districts.	Name of Water Company giving Supply in the District.
South District—contd.			
Camberwell.		Camberwell	Southwark and Vauxhall and Lambeth.
		Peckham	Southwark and Vauxhall and Lambeth and Kent.
		St. George, Camberwell	Lambeth and Southwark and Vauxhall.
Greenwich	3,801	St. Paul, Deptford	Kent.
		St. Nicholas, Do.	Do.
		Greenwich, West	Do.
		Do., East	Do.
Lewisham	11,436	Eltham	Do.
		Lee	Do.
		Lewisham Village	Do.
		Sydenham	Lambeth.
Woolwich	7,281	Charlton	Kent.
		Woolwich Dockyard	Do.
		Do. Arsenal	Do.
		Plumstead, West	Do.
		Do., East	Do.

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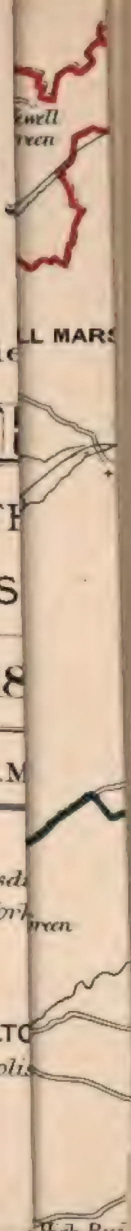

The Boundary of the jurisdi
Metropolitan Board of Wor

Prepared by

COLONEL SIR FRANCIS BOLT
Water Examiner " Metropoli

THE FOLLOWING IS A LIST OF THE DISTRICTS SUPPLIED BY THE EIGHT METROPOLITAN WATER COMPANIES AND THE NAMES OF THE PARISHES.

1. The places and parishes in which the Kent Company supply water are as follows:—

St. Paul's, Deptford.
St. Nicholas, Deptford.
Greenwich.
Woolwich.
Charlton.
Lee.
Plumstead.
Eltham.
Bromley.
Crayford.
Dartford.
Bexley.
Erith.
Chiselhurst.
Mottingham.
Kidbrooke.

And parts of the parishes of Lewisham, Camberwell, and Rotherhithe.

No part of the Company's district is jointly in supply with any other Company.

2. The places and parishes in which the New River Company supply water are as follows:—

St. Martin-in-the-Fields.
St. Paul, Covent Garden.
St. Mary-le-Strand.
St. Clement Dane
Savoy Precinct.
St. John-the-Baptist, Savoy, Strand.
St. James, Westminster.
St. Anne, Soho.
Rolls Liberty.
St. Andrew, Holborn-above-Bars.
St. George-the-Martyr.
Saffron Hill.
Hatton Garden.
Ely Rents.
Ely Place.
St. Sepulchre Without.
St. Giles-in-the-Field.
St. George, Bloomsbury.
St. James and St. John, Clerkenwell.
St. Luke, Middlesex.
St. Mary, Islington.
St. Pancras.
Holy Trinity, Minories.
St. Katherine Precincts (Docks).
The City of London.
St. Mary, Whitechapel.
Christchurch, Spitalfields.
Norton Folgate.
St. Leonard, Shoreditch.
St. John, Hackney.
St. Mary, Hornsey.

St. Mary, Stoke Newington.
Highgate Hamlet.
St. John, Hampstead.
St. Botolph, Aldgate Without.
Inner Temple.
Middle Temple.
Thavie's Inn.
Staple Inn.
Barnard's Inn.
Lincoln's Inn.
Gray's Inn.
Great and Little Amwell.
St. Margaret.
Hoddesdon.
Wormley.
Broxbourne.
Cheshunt.
Enfield.
Edmonton.
Tottenham.

The undermentioned parishes are supplied by the New River Company, in conjunction with other Companies or Boards:—

St. Martin-in-the-Fields.
St. James, Westminster.
St. Pancras.
St. Katherine Precinct.
St. Mary, Whitechapel.
Christchurch, Spitalfields.
Norton Folgate.
St. Leonard, Shoreditch.
St. John, Hackney.
St. Mary, Stoke Newington.
St. John, Hampstead.
Enfield.
Tottenham.

3. The places and parishes in which the East London Waterworks Company supply water are as follows:—

In the County of Middlesex:—

Whitechapel.
Mile End Old Town.
Mile End New Town.
Spitalfields.
Bishopsgate (part of).
Artillery Ground.
St. Botolph, Aldgate (part of).
St. George-in-the-East.
Shadwell.
Limehouse.
Wapping.
Ratcliff.
Bow.
Bromley.
Poplar.
Bethnal Green.
Shoreditch (part of).
Hackney.
Tottenham (part of).

In the County of Essex:—

West Ham.
East Ham.
Low Leyton.
Walthamstow.
Wanstead.
Woodford.
Chigwell.
Loughton.

In practice the Company do not supply any district in which another Company has pipes, but the Parliamentary district, which the Company are authorised to supply, includes:

Bishopsgate Within.	Kingsland.
St. Luke, Old Street.	Shacklewell
Stoke Newington.	and
Tottenham.	Holloway.

Which are supplied by the New River Company.

4. The places and parishes in which the Southwark and Vauxhall Waterworks Company supply water are as follows:—

Barnes.	Sheen.
Battersea.	Wandsworth.
Bermondsey.	Wimbledon (part of).
Clapham.	St. Giles, Camberwell.
East Sheen.	St. Mary, Newington.
Ham.	St. Mary, Wimbledon.
Kew.	St. Mary, Lambeth.
Mortlake.	St. Mary, Rotherhithe.
Putney.	St. Saviour's, Southwark.
Petersham.	St. John's, Southwark.
Richmond (part of).	St. Olave's, Southwark.
Roehampton.	St. Thomas, Southwark.

(Wholly or partly).

The only parts of the district supplied by the Southwark and Vauxhall Company, and also by the Lambeth Company, are parts of the parishes of

Lambeth.	Christchurch.
Newington.	Bermondsey
Camberwell.	and
St. George's.	Clapham.

5. The places and parishes in which the West Middlesex Waterworks Company supply water are as follows:—

Hampstead.	Conjointly	with the	New River Company.
St. Pancras.	"	"	do.
St. Ann's, Soho.	"	"	do.
St. James, Westminster.	"	"	do.
St. Marylebone.	"	"	Grand Junction Coy.
Paddington.	"	"	do.
Chiswick.	"	"	do

Hammersmith.	Conjointly with the Grand Junction Co.		
Kensington.	"	"	do. and Chelsea Coys.
Chelsea.	"	"	Chelsea Coy.
St. Margaret's, Westminster.	"	"	do.
Fulham.	"	"	do.

Also the Suburban parishes of Willesden and Hendon, in which places there is no other Water Company.

6. The places and parishes in which the Grand Junction Waterworks Company supply water are as follows:—

St. James, Westminster (part of).
St. George's, Hanover Square (the inward of).
St. Marylebone (part of).
Paddington.
Kensington (North part of).
Hammersmith (part of).
Chiswick.
Acton.
Ealing.
New Brentford.
Heston.
Hounslow.
Isleworth.
Hanwell.
Twickenham.
Hampton.
Hampton Wick.
Teddington.
Hampton Court.
Bushey Park.
Whitton.
Hanworth.

The only portion of the district supplied by the Grand Junction Company, and also by another Company, is a part of Paddington, and a small part of Kensington, in which the West Middlesex Company have pipes also.

7. The places and parishes in which the Lambeth Waterworks Company supply water are as follows:—

Thames Ditton.
Esher.
Long Ditton.
Kingston-upon-Thames.
Maldon.
Morden.
Wimbledon.
Merton.
Mitcham.
Tooting Graveney.
Clapham.
Wandsworth.
Battersea.
Streatham.
Croydon.
St. Mary, Newington.
Camberwell.
Bermondsey.
St. Mary, Lambeth.
St. Saviour.
St. George-the-Martyr.
Christchurch.

in the County of Surrey, and such part of the parishes of Beckenham and Lewisham as lie on the western side of the River Ravensbourne.

A portion of the district is also supplied by the Southwark and Vauxhall Company.

8. The places and parishes in which the Chelsea Waterworks Company supply water are as follows:—

St. Luke, Chelsea.
All Saints, Fulham (part of).
St. Mary Abbott's, Kensington (part of).
Kensington Palace and Precincts thereof.
St. George, Hanover Square (the out-wards).
St. James, Westminster (part of).
St. Martin-in-the-Fields (part of).
St Margaret, Westminster.
St. John the Evangelist, Westminster.

The Chelsea Company supply the whole of the district with the exception of the public buildings in the neighbourhood of Whitehall and Palace Yards, which are supplied by Government.

TABLE No. 1.—THE KENT WATERWORKS.

Source of Supply or Intake.	Situation of Works.	Average Daily Supply. Gallons.	Approximate per-centage delivered for other than domestic purposes.	Number of Supplies to Houses, &c., returned.	Number of Houses on constant Supply.	Estimated population supplied within the Districts of the Water Companies.	Storage Filtered Water Covered Reservoirs within the Radius prescribed. No.	Capacity. Gallons.	Engine Power. No.	Horse power.	Number of Miles of Mains.	Number of Miles of Mains in the Metropolis.	Number of Miles of Streets with Mains constantly charged within the Metropolis.	Number of Street Hydrants and private Fire-cocks erected within the Metropolis.	Greatest lift by Steam Power.	Head of Pressure in the District supplied. Greatest.	Least.
															Feet.	Feet.	Feet.
Ten chalk wells, namely:— Deptford, 3; Plumstead, 1; Shortlands, 2; Crayford, 3; Farnborough, 1.	. . . . . .	9,337,644	20	60,672	28,789	364,032	..	..	..	..	443	275	85	554	300	250	..
	New Cross . .	..		..	..	..	1	1,750,000	..	..				on public roads.	..	..	50
	Deptford . .	..		..	..	..	2	2,000,000	8	858					..	..	..
	Woolwich Com.	..		..	..	..	1	1,500,000	..	..					..	..	..
	Plumstead Com.	..		..	..	..	2	850,000	1	63			475		..	..	..
	Greenwich Park	..		..	..	..	1	1,125,000	..	..			in Government	Establishments.	..	..	..
	Chislehurst .	..		..	..	..	1	450,000	..	..			257		..	..	..
	Shortlands . .	..		..	..	..	..	..	2	93			Private.		..	..	..
	Crayford . .	..		..	..	..	..	..	3	186			180	for road watering.	..	..	..
	Dover Road . Shooter's Hill .	..		..	..	..	1	300,000	2	47					..	..	..
	Farnborough .	..		..	..	..	1	1,400,000	1	120					..	..	..
	Dartford . .	..		..	..	..	1	370,000	..	..					..	..	..
	Total of Kent Waterworks	9,337,644	..	60,672	28,789	364,032	11	9,745,000	17	1,367	443	275	85	1,466	..	..	..

HE NEW RIVER

..	..	..	.	Thames sand 3 ft. 0 in.	2	$3\frac{3}{4}$
00,000	..	..	.	Shells, &c. . 1 0	..	..
00,000	..	..	$7\frac{1}{2}$	Coarse gravel 3 0	..	..
..	2	12,000,	.			
..	2	7,500,	.			
..	1	2,500,	.			
..	1	615,	.			
..	1	1,150,	.			
..	1	5,000,	.			
000,000	8	28,765,	$7\frac{1}{2}$	7' 0"	2	$3\frac{3}{4}$

HE CHELSEA W

..	..	..	.	Thames sand 4 ft. 6 in.	$1\frac{3}{4}$	4
00,000	..	..	.	Shells, &c. . 0 3	..	..
..	..	..	$6\frac{3}{4}$	Gravel . . 3 3	..	..
..	{ 1 / 2	10,000, / 1,000,			..	..
00,000	3	11,000,	$6\frac{3}{4}$	8' 0"	$1\frac{3}{4}$	4

OF THE LONDON IT WILL BE SEEN
OR THE METROP

Subsiding and S Reservoirs Unfiltered W			Number of Street Hydrants and private Fire-cocks erected within the Metropolis.	Filters.		
				Filter Beds.		No. of Acres of Filter Beds cleaned during the Month.
No.	Area in Acres.	Ava		No.	Area in Acres.	
54	$465\frac{1}{2}$	1,	{ 6,724 hydrants. }	96	97	60

To face page 504.

CHAPTER VI.—QUALITY OF WATER AND WATER ANALYSES.

THE published Reports on the Analysis of the Waters supplied by the Metropolitan Water Companies during the year 1883, (1) by Professor Frankland, D.C.L., F.R.S., and (2) by Messrs. W. Crookes, F.R.S., W. Odling, M.B., F.R.S., F.R.C.P., and Dr. C. Meymott Tidy, M.B., F.C.S., give the best information obtainable respecting the quality of the London Water Supply.

These Reports may be regarded, on the principle of *ex uno disce omnes*, as typical of annual reports generally. That the authorities should not be altogether in accord in their views respecting the quality of the water supplied, is scarcely surprising when it is remembered that they have absolutely no recognised standard to guide them. It should not, however, be forgotten with regard to "organic impurity" that not only is the amount present in filtered Thames water infinitesimal in actual quantity, but we have the distinct opinion of the last Royal Commission on Water Supply—an opinion arrived at after hearing very varied and often contradictory evidence—that the presence of a small quantity of organic matter in drinking water is not necessarily prejudicial.

(1.) Professor Frankland reports:—"Since I first commenced the regular analysis of monthly samples of the London waters in 1865, important changes have taken place both on the banks of the rivers from which the greater part of the supply is derived and also in the works of the respective companies to whom that supply is entrusted. In the year 1865 all the large towns in the basins of the Thames and Lee which were provided with a sewerage system, freely discharged their raw sewage into these

rivers or their tributaries, and as each year added to the number of such towns, the amount of untreated sewage gaining access to the rivers was an ever-increasing one. The water companies, on the other hand, being ill provided either with storage reservoirs or filtering appliances, were compelled to draw from the rivers in time of flood, and the water so drawn was not, by their treatment, rendered even clear and colourless to the eye. Under these circumstances it was not surprising that chemical analysis frequently discovered an excessive proportion of organic matter in the water delivered to consumers.

"In 1869 the Royal Commission on Water Supply, in summing up their conclusions as to the quality of the water supplied from the Thames basin, state:—'That when efficient measures are adopted for excluding the sewage and other pollutions from the Thames and the Lee, and their tributaries, and for ensuring perfect filtration, water taken from the present sources will be perfectly wholesome, and of suitable quality for the supply of the Metropolis.' Although there have been great improvements made in the disposal of the sewage of many of the larger towns since 1869, yet none of these improvements have taken the form of sewage exclusion. It is sewage-purification that has been attempted and not sewage-exclusion. Indeed the expense involved in carrying out any scheme for excluding the sewage from the rivers is so great as to render such a plan practically impossible. The methods adopted for cleansing the sewage of the principal towns in the Thames basin are chiefly the application of the sewage to land, either by way of irrigation or of intermittent downward filtration. In a few instances methods of chemical treatment are employed either alone or in conjunction with the first-named methods. Irrigation and intermittent downward filtration, when properly carried out, yield equally good results, whilst the various methods of chemical treatment effect comparatively little improvement in the sewage, excepting so far as the coarser matters in suspension are concerned. The adoption of these

several methods of purification contributes greatly to improvement in the appearance and even the chemical quality of the river waters; yet it must not be forgotten that there is not one of these processes, even when carried out with the greatest care and efficiency, that offers any sort of guarantee against the admission into the Thames and Lee of noxious ingredients which may at any time be present in sewage, and which are capable of spreading zymotic disease. The chance of such morbific matter gaining access to the river waters is, by these processes of purification, no doubt diminished; but in the interests of the public health, the fact ought not to be ignored that there is at present no evidence whatever that these processes are effective either for the retention or destruction of zymotic poisons sometimes present in sewage. In the smaller towns and villages, comprising the greater portion of the population of the Thames basin, the sewage is generally allowed to collect in cesspits, the overflow from which usually communicates with the nearest stream or watercourse, whilst in other cases the street drains are utilized for conveying the sewage matters into the nearest running water. It thus appears that, notwithstanding the improvements in the disposal of town-drainage, the river Thames still receives much raw sewage matter, together with the affluents from the sewage-works which have been constructed in many places. Indeed the task of banishing these and other objectionable pollutions from the river is an entirely hopeless one.

"In dealing with the raw material thus supplied to them, very great improvements have been effected by the water companies; these have consisted chiefly in an increased accommodation for storage and the construction of more efficient filtering appliances. The result of these improvements has been that water of much more uniform quality throughout the year, is now distributed, and that it is, in nearly all cases, clear and bright to the eye. Thus whilst in the year 1868, out of 84 samples of river water examined there were only 48 clear and transparent, in the past year

there were, out of the same number of samples, no less than 73 clear and transparent. Moreover, of the 11 turbid samples in the past year, all were only 'slightly turbid,' and none 'very turbid' or 'turbid'; whilst in 1868 out of 36 turbid samples, 20 were 'slightly turbid,' 9 'turbid,' and 7 'very turbid.' The occurrence of moving organisms amongst the suspended matters of these turbid waters is now much rarer than formerly. Thus in the year 1869 these organisms were seen 24 times or in 80 per cent. of the turbid samples, whilst last year they have only been discovered on six occasions, or in 55 per cent. of the turbid samples.

"Nevertheless, in wet seasons, when the rivers are in protracted flood, the water distributed in London generally contains a very large proportion of organic matter; thus even as recently as 1880 the water supplied both from the Thames and the Lee contained a greater average proportion of organic matter than in any year since these analyses have been made. But even with the proportion of organic matter at its minimum there is no certainty that the water does not contain the germs of zymotic disease; for, as I have already stated, there is still no guarantee against such morbific matters gaining access to the rivers, and there is nothing in the subsequent treatment to which the river water is subjected by the companies that will ensure the removal of matters of this description. It has been recently shown, that filtration through far greater thicknesses of sand than could be employed on the large scale by water companies is quite insufficient to remove those lower forms of living matter which, in their habits, we have good reason to believe, simulate the organisms causing zymotic disease. Indeed I am informed that several of the water companies themselves are now impressed with the necessity of ultimately abandoning the rivers Thames and Lee as sources of water supply, and some of them have already completed works for utilizing subterranean waters which have undergone natural filtration through great thicknesses of gravel and sand, whilst others are sinking deep wells into the

chalk. In the interest of the public health, it is to be hoped that works of this description will be continued and receive every encouragement.

"During the year 1883 the average daily volume of water supplied to the inner circle of the Metropolis by the eight companies, amounted to 144,592,772 gallons. Although this quantity is upwards of three millions of gallons in excess of the previous year, yet the average consumption per head of population was almost exactly the same, amounting to 28·4 gallons per day as against 28·6 in 1882. Of this total supply, 9,567,634 gallons from deep-wells in the chalk were of uniformly good quality throughout the year, whilst the remainder, consisting of 71,710,878 gallons from the Thames, and 63,314,260 gallons from the Lee, was open to the before-mentioned objections urged against the river waters. The samples analysed were in all cases taken directly from the mains at places recommended by the companies themselves.

"The temperature of each sample at the time of collection was observed, and its appearance in a two-foot tube has also been recorded; whilst in the case of those samples found to be more or less turbid the suspended matter deposited on standing was submitted to microscopical examination.

"In Table A the temperature of the waters as they issued from the companies' mains is recorded. In this respect the waters exhibited the following variations:—

"The Thames water distributed by the Chelsea, West Middlesex, Southwark, Grand Junction, and Lambeth Companies varied in temperature from 3·1° C. (37·6° Fahr.) in March to 22·0° C. (71·6° Fahr.) in July.

"The temperature of the water abstracted from the Lee and sent out by the New River and East London Companies showed a variation from 3·4° C. (38·1° Fahr.) in March to 20·0° C. (68·0°F ahr.) in July.

"The deep-well water of the Kent Company varied in temperature from 3·4° C. (38·1° Fahr.) in March, to 15·5° C. (59·9° Fahr.) in June.

"Thus the temperature of the river waters was subject to greater variation than that of the deep-well water, the latter remaining of an agreeable coolness in summer, when the river waters became warm and unpalatable.

"Table B shows the total amount of solid matters present in 100,000 parts by weight of each of the waters. A very large proportion of this solid matter consists of mineral salts, which are quite unobjectionable in drinking water, but as they render the water hard, they make it less suitable for washing and for most manufacturing purposes.

"A small proportion of this solid matter, on the other hand, is organic. Small quantities of vegetable organic matter are not objectionable in drinking water, but the organic matter in river water which receives sewage may at any time become dangerous to health. The greatest amount of total solid matters was found in the deep-well water supplied by the Kent Company and by the Tottenham Local Board of Health, whilst the Colne Valley Company's water, although derived from the same source, contained but little more than one-third of that amount, and little more than one-half of that present in any of the river waters. This reduction in the amount of solid matters present in the water of the Colne Valley Company is effected by the application of Clark's process of softening, which consists in adding to it a small quantity of slaked lime. The solid matters in the other Metropolitan waters would be reduced to about the same amount by similar treatment.

"Tables C and D record the proportion in which organic matter was present in the waters, as indicated by the amount of organic carbon and nitrogen found by combustion. The importance of these tables is obvious when it is remembered that the organic matter in the river water is, to no small extent, derived from animal sources, such as raw sewage, the effluent from sewage works, and the drainage from manured land. From these tables it will be seen that during an unusually large part of the year the amount of organic matter in the river waters was ex-

ceptionally small, although the difference between the quality of the water in summer and winter was still sufficiently marked. The deep-well water, on the other hand, was not only superior to the river waters, when at their best, but maintained its good quality throughout the year.

"Taking the mean proportion of organic impurity contained in the Thames water delivered in 1868 as 1000, I find that in the subsequent years, 1883 included, the following proportions were present:—

Year.	Proportion of organic impurity present in Thames water as delivered in London.
1868	1,000
1869	1,016
1870	795
1871	928
1872	1,243
1873	917
1874	933
1875	1,030
1876	903
1877	907
1878	1,056
1879	1,165
1880	1,254
1881	993
1882	1,033
1883	850

"It thus appears that in the past year, the water drawn from the Thames was of better average quality than in any previous year, excepting 1870, since these analyses have been made.

"The water drawn from the Lee and distributed by the New River and East London Companies was uniformly of better average quality than that from the Thames. The New River Company's supply was in every case superior to that of the East London Company.

"Taking, as before, the mean proportion of organic impurity in the Thames water supplied to London in 1868 as 1000, I find in that and the succeeding years, 1883

included, the following proportions in the Lee water delivered by the New River and East London Companies :—

Year.	Proportion of organic impurity present in Lee water as delivered in London.
1868	484
1869	618
1870	550
1871	604
1872	819
1873	693
1874	583
1875	751
1876	562
1877	596
1878	747
1879	947
1880	1,013
1881	765
1882	711
1883	620

"These figures show that during the past year the condition of the water supplied from the Lee was better than in any of the previous years since 1877.

"In the case of the deep-well waters supplied to London, the organic matter, when compared with the same standard, was :—

1868	254
1869	312
1870	246
1871	150
1872	221
1873	250
1874	287
1875	250
1876	246
1877	243
1878	323
1879	387
1880	393
1881	405
1882	409
1883	321

"The proportion of organic matter present in the deep-well waters was thus but little more than one-half that in the Lee, and considerably less than one-half of that in the Thames. The amount would have been still less but for extensive alterations which were being made at the works of the Tottenham Local Board of Health, in consequence of which the deep-well waters had to be supplemented by water obtained from the mains of the East London Company. The execution of such alterations in deep-wells, which are in active use, is attended with considerable danger to the consumers, as was demonstrated some years since at Caterham, where the excrements of a workman suffering from a slight attack of typhoid fever gained access to the well and were the means of simultaneously communicating this disease to a large number of persons both in Caterham and in the town of Red Hill some eight miles distant. In the interest of the public health, such alterations should be carried on under medical supervision.

"From a sanitary point of view the superiority of the deep-well over the river water is really much greater than a comparison of the above figures would indicate, for the thorough process of natural filtration, which the deep-well water has undergone in passing through a great thickness of porous strata, renders it extremely improbable that any of those suspended particles, which may become prejudicial to health, should have escaped removal.

"Unfortunately the protection from pollution, which is afforded by the common law to rivers, is at present denied to subterranean waters. That the latter may now be polluted to an unlimited extent without remedy was shown by the judgment of Mr. Justice Pearson in an action, Ballard *v.* Tomlinson, recently heard in the Court of Chancery. It is most desirable that these invaluable subterranean sources of pure water should be carefully protected by law.

"In Table E is recorded the proportional amount of organic

elements (organic carbon and organic nitrogen) in each of the waters, the average amount of these elements contained in the Kent Company's water during the nine years ending December, 1876, being taken as unity. This Table shows that the maximum, minimum, and average proportions of organic matter, as measured by this standard, present in the several waters during 1883 were as follows:—

Sources.		Maximum.	Minimum.	Average.
Deep wells	Kent	1·5	0·9	1·1
	Colne Valley	1·5	1·0	1·2
	Tottenham	2·3	1·1	1·7
River Lee	New River	3·6	1·3	2·2
	East London	5·0	1·9	2·9
River Thames	Chelsea	4·7	2·0	3·1
	West Middlesex	5·7	2·0	3·7
	Southwark	6·6	1·9	3·6
	Grand Junction	5·3	2·4	3·4
	Lambeth	5·7	2·0	3·6

"These figures clearly illustrate that the deep-well waters remain of nearly uniform purity throughout the year, whilst the river waters, although exceptionally free from excessive pollution during the past year, exhibit very marked fluctuations. Of the deep-well water that supplied by the Kent Company was the best, whilst of the river water the New River Company's supply was the best, and that of the West Middlesex Company the worst, the Chelsea Company's supply ranking first amongst the Thames derived waters.

"The following Table shows the maximum amount of organic pollution in the waters supplied from the Thames and Lee during the years 1868 to 1883 inclusive, the average of the samples in the month of greatest pollution being taken for comparison:—

"MAXIMUM AMOUNT OF ORGANIC POLLUTION.

Thames.			Lee.		
Year.	Elements of organic matter in parts per 100,000.	Months in which maximum pollution occurred.	Year.	Elements of organic matter in parts per 100,000.	Months in which maximum pollution occurred.
1868	·45	January.	1868	·27	February.
1869	·60	February.	1869	·33	February.
1870	·42	January.	1870	·30	January.
1871	·52	October.	1871	·22	February.
1872	·48	Jan. and Dec.	1872	·39	December.
1873	·46	January.	1873	·33	January.
1874	·37	March.	1874	·21	March.
1875	·49	November.	1875	·28	November.
1876	·44	December.	1876	·24	March.
1877	·40	January.	1877	·30	January.
1878	·36	December.	1878	·26	June.
1879	·38	February.	1879	·33	July.
1880	·42	October.	1880	·33	February.
1881	·34	February.	1881	·34	February.
1882	·37	November.	1882	·26	December.
1883	·32	January.	1883	·24	December.

"Thus the waters, both from the Thames and the Lee, were during the past year exceptionally free from excessive pollution. The recent improvement in this respect is especially marked in the case of the Thames, and is to be attributed to the action of the Board of Conservators and to the greater storage capacity with which the companies drawing from this river are now provided, as already pointed out.

"Tables F and G require no comment.

"Table H records the total amount of combined nitrogen, which, after making a small deduction for the average quantity contained in rain water, constitutes the total evidence of both past and present contamination with nitrogenous organic matters which the waters have suffered. In river water, however, the quantity of total combined nitrogen is considerably reduced during the summer months by the presence of active vegetable and animal life, and it is, therefore, only in the autumn and winter months that it can be regarded as any measure of pollution. During the

months of January, February, March, October, November, and December 1879, the average proportion of total combined nitrogen in 100,000 parts of Thames water was ·281 part, in 1880 ·276, ·260 in 1881, ·258 in 1882, and last year ·259 part. The continuous diminution, which has thus taken place, is doubtless due to the longer storage to which the water has in recent years been subjected.

"In the same quantity of water supplied during the same months from the Lee, the average total combined nitrogen was ·310 part in 1879, ·284 in 1880, ·294 in 1881, ·304 in 1882, and ·329 in last year. No diminution, but, on the contrary, rather an increase in the amount of total combined nitrogen has thus taken place.

"The deep-well water distributed by the Kent and Colne Valley Companies and by the Tottenham Local Board of Health is not subject to the influence of animal or vegetable life, and the average of the total combined nitrogen may therefore be taken on the whole year. In 1879 it was ·317 part, ·294 in 1880, ·306 in 1881, ·294 in 1882, and ·353 part last year.

"In Table I is recorded the proportion of chlorine present in each of the waters. The figures show that no brackish or tidal water gained access to the companies' reservoirs.

"Table K shows the hardness of the various waters. By hardness is to be understood the weight of carbonate of lime, or its equivalent of other soap-destroying substances, present in 100,000 parts of water.

"The average hardness of the Thames water delivered in London, was 20·8° in 1879, 20·2° in 1880, 19·8° in 1881, 20·7° in 1882, and 19·9° in 1883; of the Lee, 21·4° in 1879, 20·7° in 1880, 20·8° in 1881, 21·1° in 1882, and 20·6° in last year; of the Kent Company's water, 28·4° in 1879, 26·6° in 1880, 28·3° in 1881, 28·5° in 1882, and 28·0° in 1883; of the Colne Valley Company's water, 6·3° in 1879, 6·3° in 1880, 6·2° in 1881, 5·5° in 1882, and 7·1° in 1883; and of the water sent out by the Tottenham Local Board of Health, 25·6° in 1879, 22·2° in 1880, 24·1° in 1881, 25·4° in 1882, and 22·5° last year.

"Soft water is absolutely necessary for the washing of linen, and if the water be not naturally so, it has to be softened by means of carbonate of soda, or soap, before being employed for that purpose. This process of softening with soap in the laundry entails an expense about 80 times as great as when the same is done on the large scale by a water company. All the water delivered in London, excepting that of the Colne Valley Company, was unsuitable for washing. The water drawn by the Colne Valley Company from the chalk is naturally hard, but is rendered soft by means of Clark's process before distribution.

"Table L, lastly, records the average, for the past year, of each determination already specified, and thus summarizes the results of the analyses of the water supplied by each company during the year.

"The results of my observations respecting the efficiency of the filtration to which the waters of the Thames and Lee were subjected by the various companies during the past year are contained in the following Table:—

Companies or Local Authorities.	Number of occasions when clear and transparent.	Number of occasions when slightly turbid.	Number of occasions when turbid.	Number of occasions when very turbid.
THAMES.				
Chelsea	11	1	0	0
West Middlesex ..	11	1	0	0
Southwark ..	7	5	0	0
Grand Junction ..	9	3	0	0
Lambeth	11	1	0	0
LEE.				
New River ..	12	0	0	0
East London ..	12	0	0	0
DEEP WELLS.				
Kent	12	0	0	0
Colne Valley ..	12	0	0	0
Tottenham Local Board of Health	11	0	0	1

"Thus, of the river water, only that sent out by the

New River and East London Companies was uniformly clear.

"As already pointed out, nothing furnishes more conspicuous proof of the improvements which have been effected in the companies' works than the comparative freedom from turbidity which the river waters now exhibit.

"The deep-well water supplied by the Kent and Colne Valley Companies and by the Tottenham Local Board of Health is uniformly clear and bright, and requires no artificial filtration. The turbid sample of the Tottenham water was collected at a time when alterations were being made in the bore-hole, and is thus accounted for.

"The sediment deposited by the turbid waters on standing was in every case examined microscopically. During the past year these examinations revealed the presence of moving organisms in no less than three samples of the Southwark Company's water, whilst one sample of the Chelsea, Grand Junction, and Lambeth Companies' waters respectively exhibited the same phenomenon, as did also the turbid sample of the Tottenham water.

"In the following Table the results of these microscopic examinations, made during the past 15 years, are collected:—

NUMBER of Occasions when MOVING ORGANISMS were found.

—	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.
Chelsea	3	2	2	3	2	5	4	4	1	0	2	0	0	0	1
West Middlesex	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0
Southwark ..	8	1	4	1	2	5	5	7	5	3	0	0	0	0	3
Grand Junction	4	1	1	2	3	5	7	3	3	3	1	3	3	0	1
Lambeth ..	5	0	4	6	3	4	5	4	1	1	0	2	1	1	1
New River ..	0	0	0	0	1	1	0	0	1	0	0	2	0	0	0
East London ..	4	3	3	1	0	2	0	0	0	0	2	0	0	1	0
Kent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colne Valley ..	–	–	–	–	–	–	–	–	0	0	0	0	0	0	0
Tottenham ..	–	–	–	–	–	–	–	–	0	0	0	0	0	0	1

TABLE A.

TEMPERATURE (IN CENTIGRADE DEGREES) OF THE METROPOLITAN WATERS, AS DELIVERED FROM THE DIFFERENT COMPANIES' MAINS.

	Companies or Local Authorities.	1883. Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Inner Circle.	THAMES.													
	Chelsea	8·7	7·4	4·8	10·4	15·2	16·1	17·7	17·0	16·0	13·4	9·0	7·7	11·9
	West Middlesex	9·1	6·8	4·8	12·1	13·2	19·4	22·0	19·5	18·2	13·6	7·3	6·6	12·7
	Southwark	9·1	6·4	4·0	12·4	18·0	18·0	22·0	19·8	18·1	14·0	7·6	5·8	12·9
	Grand Junction	8·0	6·2	3·5	11·5	12·4	18·0	20·8	18·8	17·5	13·0	11·1	5·5	12·2
	Lambeth	8·5	7·0	3·1	10·9	16·0	16·6	20·0	18·2	16·9	12·7	6·7	4·9	11·8
	LEE.													
	New River	8·8	5·9	4·9	10·7	11·0	18·3	20·0	18·0	17·2	13·0	6·8	6·7	11·8
	East London	8·0	5·8	3·4	11·0	11·2	17·9	19·5	18·3	17·3	12·9	6·4	5·1	11·4
	DEEP WELLS.													
	Kent	6·8	7·2	3·4	14·1	15·0	15·5	14·5	15·2	15·0	14·4	12·0	12·5	12·1
Outer Circle.	Colne Valley	11·1	..	..	..	..	..	..	..	..	..	..	..	..
	Tottenham Local Board	..	..	..	..	..	..	..	..	16·0	..	..	..	..

TABLE B.

WEIGHT OF SOLID MATTERS IN 100,000 PARTS OF THE WATERS.

	Companies or Local Authorities.	1883. Jan.	Feb.	March.	April.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Inner Circle.	THAMES.													
	Chelsea . . .	31·16	29·58	27·84	25·92	24·56	24·20	26·34	24·80	25·62	26·20	29·04	30·14	27·12
	West Middlesex .	29·68	29·60	29·62	25·96	26·32	25·60	24·92	24·78	25·66	27·72	31·10	32·14	27·76
	Southwark . .	28·94	27·92	30·64	27·58	25·18	26·12	26·70	25·94	26·00	29·22	32·36	32·08	28·22
	Grand Junction .	30·08	28·80	30·30	27·30	28·06	25·62	26·46	25·42	25·54	24·36	32·16	32·80	28·07
	Lambeth . . .	30·14	30·20	32·10	28·98	28·46	27·20	27·48	25·94	27·76	30·72	30·84	32·82	29·39
	LEE.													
	New River . .	31·68	33·16	30·44	26·56	25·12	25·48	26·50	25·38	26·44	28·58	31·02	31·40	28·48
	East London . .	36·50	34·86	32·32	26·62	27·54	26·28	27·70	27·02	23·58	30·46	33·18	35·42	30·12
	DEEP WELLS.													
	Kent	44·86	46·16	43·00	38·78	40·04	39·72	43·86	40·26	38·40	38·68	43·44	43·30	41·71
Outer Circle.	Colne Valley . .	14·96	17·30	16·30	14·90	12·96	16·26	27·62	14·12	12·98	13·30	12·70	13·28	15·56
	Tottenham Local Board . . .	41·14	46·00	43·70	38·00	37·00	36·40	36·12	36·70	37·62	41·52	37·34	36·92	39·04

TABLE C.

ORGANIC CARBON IN 100,000 PARTS OF THE WATERS.

	Companies or Local Authorities	1883. Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Inner Circle.	THAMES.													
	Chelsea	·228	·239	·207	·111	·104	·122	·101	·123	·102	·170	·169	·194	·156
	West Middlesex .	·284	·288	·206	·111	·144	·119	·109	·124	·105	·215	·224	·285	·184
	Southwark . . .	·347	·257	·115	·097	·145	·141	·161	·124	·127	·222	·223	·247	·184
	Grand Junction .	·271	·231	·118	·108	·123	·127	·123	·137	·124	·174	·187	·242	·164
	Lambeth . . .	·264	·290	·123	·110	·171	·134	·153	·135	·102	·209	·258	·263	·184
	LEE.													
	New River . . .	·168	·182	·120	·080	·104	·066	·071	·078	·057	·086	·114	·151	·106
	East London . .	·192	·201	·160	·095	·148	·099	·092	·121	·111	·136	·160	·267	·148
	DEEP WELLS.													
	Kent	·069	·053	·040	·054	·043	·050	·048	·042	·040	·037	·057	·062	·050
Outer Circle.	Colne Valley . .	·070	·049	·056	·058	·046	·048	·043	·047	·047	·054	·059	·055	·053
	Tottenham Local Board . . .	·081	·081	·077	·059	·076	·112	·042	·065	·069	·100	·074	·084	·077

TABLE D.

ORGANIC NITROGEN IN 100,000 PARTS OF THE WATERS.

	Companies or Local Authorities.	1883. Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Inner Circle.	THAMES.													
	Chelsea . . .	·033	·041	·050	·032	·021	·019	·027	·032	·018	·025	·024	·040	·030
	West Middlesex .	·044	·048	·043	·030	·032	·014	·019	·020	·015	·031	·051	·046	·033
	Southwark . .	·042	·050	·024	·016	·041	·019	·031	·016	·020	·024	·026	·041	·029
	Grand Junction .	·043	·044	·034	·038	·031	·017	·031	·021	·027	·060	·023	·039	·034
	Lambeth . . .	·027	·049	·032	·038	·041	·021	·020	·018	·019	·026	·029	·038	·030
	LEE.													
	New River . .	·033	·030	·028	·020	·021	·013	·019	·017	·018	·017	·014	·025	·021
	East London . .	·036	·034	·020	·019	·024	·014	·024	·020	·026	·036	·020	·030	·025
	DEEP WELLS.													
	Kent	·019	·016	·016	·015	·012	·015	·017	·017	·016	·017	·006	·010	·015
Outer Circle.	Colne Valley . .	·019	·022	·019	·010	·011	·014	·019	·019	·010	·014	·021	·020	·016
	Tottenham Local Board . . .	·026	·028	·023	·008	·042	·022	·023	·017	·010	·023	·018	·027	·022

TABLE E.

PROPORTIONAL AMOUNT OF ORGANIC ELEMENTS, THAT IN THE KENT COMPANY'S WATER DURING THE NINE YEARS ENDING DECEMBER 1876 BEING TAKEN AS 1.

	Companies or Local Authorities.	1883.												
		Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Inner Circle.	THAMES.													
	Chelsea	4·4	4·7	4·3	2·4	2·1	2·4	2·2	2·6	2·0	3·3	3·3	4·0	3·1
	West Middlesex	5·5	5·7	4·2	2·4	3·0	2·2	2·2	2·4	2·0	4·2	4·7	5·6	3·7
	Southwark	6·6	5·2	2·3	1·9	3·2	2·7	3·2	2·4	2·5	4·2	4·2	4·9	3·6
	Grand Junction	5·3	4·7	2·6	2·5	2·6	2·4	2·6	2·7	2·6	4·0	3·6	4·8	3·4
	Lambeth	4·9	5·7	2·6	2·5	3·6	2·6	2·9	2·6	2·0	4·0	4·9	5·1	3·6
	LEE.													
	New River	3·4	3·6	2·5	1·7	2·1	1·3	1·5	1·6	1·3	1·7	2·2	3·0	2·2
	East London	3·9	4·0	3·1	1·9	2·9	1·9	1·9	2·4	2·3	2·9	3·1	5·0	2·9
	DEEP WELLS.													
	Kent	1·5	1·2	0·9	1·2	0·9	1·1	1·1	1·0	0·9	0·9	1·1	1·2	1·1
Outer Circle.	Colne Valley	1·5	1·2	1·3	1·2	1·0	1·1	1·1	1·1	1·0	1·1	1·4	1·3	1·2
	Tottenham Local Board	1·8	1·8	1·7	1·1	2·0	2·3	1·1	1·4	1·3	2·1	1·6	1·9	1·7

TABLE F.

AMMONIA IN 100,000 PARTS OF THE WATERS.

	Companies or Local Authorities.	1883. Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Inner Circle.	THAMES.													
	Chelsea . . .	0	·001	0	0	0	0	0	·001	0	·001	0	0	0
	West Middlesex .	0	0	0	0	0	0	0	0	0	0	0	0	0
	Southwark . .	0	0	0	0	0	0	0	0	0	0	0	0	0
	Grand Junction .	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lambeth . . .	0	0	0	0	0	0	0	0	0	0	0	0	0
	LEE.													
	New River . .	0	0	0	0	0	0	0	0	0	0	0	0	0
	East London . .	0	0	0	0	0	0	0	0	0	0	0	0	0
	DEEP WELLS.													
	Kent	0	0	0	0	0	0	0	0	0	0	0	0	0
Outer Circle.	Colne Valley . .	0	0	0	0	0	0	0	0	·002	0	·001	·010	·001
	Tottenham Local Board . . .	·065	·048	·050	·055	·050	·060	·050	·075	0	·030	·060	·055	·050

TABLE G.

NITROGEN AS NITRATES AND NITRITES IN 100,000 PARTS OF THE WATERS.

	Companies or Local Authorities.	1883. Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Inner Circle.	THAMES.													
	Chelsea . . .	·199	·212	·214	·236	·181	·170	·196	·142	·156	·184	·206	·221	·193
	West Middlesex .	·245	·227	·264	·244	·236	·175	·172	·157	·168	·148	·217	·216	·206
	Southwark . .	·186	·194	·329	·210	·196	·175	·160	·169	·163	·222	·262	·231	·206
	Grand Junction .	·141	·177	·309	·241	·207	·180	·169	·172	·179	·123	·227	·258	·199
	Lambeth . . .	·179	·204	·394	·269	·249	·205	·197	·190	·209	·237	·218	·234	·232
	LEE.													
	New River . .	·339	·312	·375	·294	·243	·192	·194	·188	·210	·255	·292	·288	·265
	East London . .	·308	·312	·320	·241	·227	·183	·185	·155	·137	·251	·259	·304	·240
	DEEP WELLS.													
	Kent	·514	·469	·376	·393	·465	·521	·477	·532	·473	·420	·473	·523	·470
Outer Circle.	Colne Valley . .	·467	·565	·548	·527	·496	·406	·384	·368	·371	·351	·376	·411	·439
	Tottenham Local Board . . .	0	0	0	0	0	0	0	0	·303	·378	0	0	·057

TABLE H.

TOTAL COMBINED NITROGEN IN 100,000 PARTS OF THE WATERS.

	Companies or Local Authorities.	1883.												
		Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Inner Circle.	THAMES.													
	Chelsea . . .	·232	·254	·264	·268	·202	·189	·223	·175	·174	·210	·230	·261	·223
	West Middlesex .	·289	·275	·307	·274	·268	·189	·191	·177	·183	·179	·268	·262	·238
	Southwark . .	·228	·244	·353	·226	·237	·194	·191	·183	·183	·246	·258	·272	·235
	Grand Junction .	·184	·221	·343	·279	·238	·197	·200	·193	·206	·183	·250	·297	·233
	Lambeth . . .	·206	·253	·426	·307	·290	·226	·217	·208	·228	·263	·247	·272	·262
	LEE.													
	New River . .	·372	·342	·403	·314	·264	·205	·213	·205	·228	·272	·306	·313	·286
	East London . .	·344	·346	·340	·260	·251	·197	·209	·175	·163	·287	·279	·334	·265
	DEEP WELLS.													
	Kent	·533	·485	·392	·408	·477	·536	·494	·549	·489	·437	·479	·533	·484
Outer Circle.	Colne Valley . .	·485	·587	·567	·537	·507	·420	·403	·387	·383	·365	·398	·439	·456
	Tottenham Local Board . . .	·080	·067	·064	·055	·083	·071	·064	·079	·313	·426	·067	·072	·120

TABLE I.

Chlorine in 100,000 parts of the Waters.

	Companies or Local Authorities.	1883. Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Inner Circle.	**Thames.**													
	Chelsea . . .	1·6	1·5	1·4	1·5	1·6	1·5	1·5	1·6	1·6	1·6	1·6	1·5	1·5
	West Middlesex .	1·5	1·5	1·4	1·5	1·7	1·6	1·5	1·5	1·5	1·5	1·5	1·5	1·5
	Southwark . .	1·5	1·4	1·5	1·5	1·7	1·5	1·5	1·6	1·6	1·5	1·5	1·5	1·5
	Grand Junction .	1·5	1·5	1·5	1·5	1·7	1·5	1·5	1·6	1·5	1·5	1·5	1·5	1·5
	Lambeth . . .	1·6	1·7	1·6	1·5	1·7	1·5	1·5	1·6	1·5	1·5	1·5	1·5	1·6
	Lee.													
	New River . .	1·7	1·7	1·6	1·6	1·6	1·5	1·6	1·6	1·5	1·5	1·6	1·7	1·6
	East London . .	1·9	1·8	1·7	1·7	1·8	1·7	1·7	1·7	1·7	1·6	1·8	1·7	1·7
	Deep Wells.													
	Kent	2·6	2·6	2·5	2·4	2·7	2·6	2·7	2·9	2·4	2·5	2·4	2·5	2·6
Outer Circle.	Colne Valley . .	1·7	1·8	1·8	1·8	1·8	1·7	1·8	1·7	1·7	1·6	1·7	1·7	1·7
	Tottenham Local Board . . .	3·0	3·1	3·1	2·6	2·5	2·5	2·4	2·4	2·7	2·8	2·5	2·5	2·7

TABLE K.

DEGREES OF HARDNESS (1 DEG. = 1 PART OF CARBONATE OF LIME, OR ITS EQUIVALENT) IN 100,000 PARTS OF THE WATERS.

	Companies or Local Authorities.	1883. Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Inner Circle.	THAMES.													
	Chelsea . . .	20·6	20·0	19·4	18·0	16·9	18·9	19·1	18·9	18·0	18·6	20·3	20·6	19·1
	West Middlesex .	20·3	19·1	20·6	17·7	18·9	20·0	18·6	19·1	19·4	19·7	21·5	22·1	19·7
	Southwark . .	19·1	18·9	21·5	19·4	18·0	19·7	19·7	19·1	20·0	20·9	22·4	22·1	20·1
	Grand Junction .	20·3	18·6	21·2	18·6	18·6	20·0	19·4	19·4	18·9	18·3	22·4	22·7	19·9
	Lambeth . . .	20·6	19·1	21·2	20·0	19·4	20·9	20·6	19·4	20·3	21·8	21·5	22·7	20·6
	LEE.													
	New River . .	21·2	20·9	21·2	18·6	18·6	20·3	20·3	18·9	19·7	20·6	22·1	22·1	20·4
	East London . .	22·7	22·4	22·4	18·0	19·1	20·3	19·7	19·4	17·4	21·8	22·7	24·2	20·8
	DEEP WELLS.													
	Kent	29·3	27·8	26·4	24·3	26·4	28·5	30·7	29·3	27·1	27·8	27·9	30·0	28·0
Outer Circle.	Colne Valley . .	5·7	6·6	6·6	5·6	5·7	8·6	20·3	4·6	5·7	5·6	5·1	5·1	7·1
	Tottenham Local Board . . .	24·3	22·8	27·1	23·5	25·0	22·8	22·8	26·4	21·4	22·1	17·1	15·2	22·5

TABLE L.—AVERAGES FOR 1883.

THE NUMBERS IN THIS TABLE RELATE TO 100,000 PARTS OF EACH WATER.

	Companies or Local Authorities.	Temperature in Centigrade Degrees.	Total Solid Matters.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen, as Nitrates and Nitrites.	Total combined Nitrogen.	Chlorine.	Total Hardness.	Proportional Amount of Organic Elements, that, in the Kent Company's Water during the nine years ending Dec. 1876 being taken as 1.
Inner Circle.	THAMES.	°									
	Chelsea	11·9	27·12	·156	·030	·000	·193	·223	1·5	19·1	3·1
	West Middlesex	12·7	27·76	·184	·033	0	·206	·238	1·5	19·7	3·7
	Southwark	12·9	28·22	·184	·029	0	·206	·235	1·5	20·1	3·6
	Grand Junction	12·2	28·07	·164	·034	0	·199	·233	1·5	19·9	3·4
	Lambeth	11·8	29·39	·184	·030	0	·232	·262	1·6	20·6	3·6
	LEE.										
	New River	11·8	28·48	·106	·021	0	·265	·286	1·6	20·4	2·2
	East London	11·4	30·12	·148	·025	0	·240	·265	1·7	20·8	2·9
	DEEP WELLS.										
	Kent	12·1	41·71	·050	·015	0	·470	·484	2·6	28·0	1·1
Outer Circle.	Colne Valley	—	15·56	·053	·016	·001	·439	·456	1·7	7·1	1·2
	Tottenham Local Board	—	39·04	·077	·022	·050	·057	·120	2·7	22·5	1·7

NOTE.—The numbers in these tables may be converted into grains per imperial gallon, by multiplying them by 7, and then moving the decimal point one place to the left.

(2). The Report on the composition and quality of daily samples of water supplied to London during the year 1883, by Messrs. Crookes, Odling, and C. Meymott Tidy, is addressed to the Official Water Examiner for the Metropolis. From this report the following extracts are given, some passages being omitted which partake more particularly of a controversial character, and do not appear to afford any direct information on the main elements of the question :—

"We submit a statement of the general results of our examination, made at the expense of the water companies, of the 2,224 samples of water collected by us during the year 1883, from the mains and reservoirs of the seven London companies taking their supply from the Thames and the Lee.

"We may mention that from the time of commencing our monthly reports in December, 1880, we have, up to December, 1883, examined and reported on 6,524 samples of the water supplied to the metropolis.

"COLOUR OF THE WATER.—In a tabulated form will be found* recorded the results of our daily examinations of the colour exhibited by the water supplied by the several companies, as estimated by the colour meter, the construction and use of which we have fully described in our previous reports. These results are represented diagrammatically in the wave diagrams which are placed at the end of this report.

"The use of a coloured glass wedge for comparing an unknown with a known tint of colour, and for assigning to the former its true place on a graduated scale, is probably as old as quantitative analysis itself. The use of a hollow wedge, filled with coloured solution, also dates from comparatively early days, and was used in 1857 by Dr. J. H. Gladstone, in his researches on the use of the prism in qualitative analysis. We ourselves have used the hollow wedge in colorimetric experiments for more than twenty years, and in adopting two wedges, one opposed to the other, and filled respectively with blue and with brown liquid, so as almost exactly to imitate the varying tints of potable

* *See* Note to p. 540.

water, we considered we were justified, in 1881, in characterising the process as 'a great improvement over the arbitrary degrees of tint-depth by which the colour of water has hitherto been estimated.' and in 1882, as 'a great improvement on all previous means (so far as we know them) for obtaining a standard of colour.' In our annual report on the composition and quality of the London waters for 1882, we drew further attention to this colour-meter, as showing a close relationship between the organic carbon present and the colour of the water, saying that 'the relationship thus exhibited goes far to establish the usefulness of the colorimetric mode of examination introduced and employed by ourselves, and its value as an improvement on the rougher methods still in common use.'

"Our attention has lately been drawn by Professor Albert R. Leeds, of the Stevens Institute of Technology, Hoboken, New Jersey, United States, to a prior publication by him of a colorimeter, in the 'Journal of the American Chemical Society,' and in the 'Chemical News' for June 7, 1878. This consisted of one wedge filled with standard caramel solution, and capable of being moved in and out beneath flat-bottomed cylinders. In so far as Professor Leeds used the varying thickness of a standard brown solution in a hollow wedge to fix numerically the tint of water, he anticipated the method we employ, although in some points of detail, and in the principle of using two wedges filled each with a differently coloured liquid, corresponding to each of the two main contributory tints of potable water, our method differs from his. At the time of our devising the colorimeter we have since employed, we were unaware of what had been done by Professor Leeds; with whose request to us to make this explanation, recognising his claim to priority in the use of a hollow wedge colorimeter for the purpose of water examination, we willingly comply.

"In our colorimeter, the tint of colour, exhibited by a thickness of two feet of the water under examination, is compared with the conjoint tint of so many millimetres of

a particular blue solution, and of so many millimetres of a particular brown solution,—both solutions being coloured with definite mineral salts, and made of a specific strength, so as to be reproducible of exactly the same shade and depth of tint after any interval of time. As a general rule, the degree of brownish tint in the same supply of water is found to vary with the proportion of organic matter present in the water, as determined by the combustion process, and by the permanganate process. This is shown very strikingly in what we have called the mean Thames-water curves, as plotted for the past three years, 1881–83. (See Table, p. 535.) But to this general rule, occasional exceptions are presented by individual samples of water, doubtless because the fluviatile conditions affecting the constituent colorific organic matter of the water and its entire organic matter, are not identical, and because the effect of filtration upon the constituent and the entirety are also not identical.

"CLEARNESS.—We still continue the use of the phrases 'turbid,' 'slightly turbid,' 'very slightly turbid,' and 'clear.' The special meaning we attach to these arbitrary terms has been explained in our previous reports.

"The results of our examination, in respect to their state of clearness, of the 2,224 samples collected by us during the year, are duly arranged and tabulated.

"Summarising the results, we note that thirty-two samples were recorded as very slightly turbid (V. S. T.), and five as slightly turbid (S. T.), while 2,187 samples out of the 2,224 were found to be perfectly bright, clear, and well filtered. In three out of the five samples recorded as slightly turbid, the turbidity was confined to the locality from which the samples were drawn, and was dependent on the carrying out of work at the time, in connection with the supply of the neighbourhood.

"The proportion of samples found to be bright, clear, and well filtered, amounted to 91·4 per cent. in 1881; to 97·6 per cent. in 1882; and to 98·3 per cent. during the past year.

"FREE OXYGEN.—This we have recorded in cubic inches per gallon; practically, the water has been found throughout the year to be fully aërated or oxygenated. Our own

experiments, conducted now for a period of three years at the rate of about 180 a month, constitute the first consecutive series of determinations of the state of aëration of potable water hitherto carried out. Other chemists are gradually getting to recognise the value of the results afforded, and to make use of the process of free oxygen determination in their study of questions relating to water supply, and to the remarkable self-purifying power of running water, now become more than ever a matter of positive demonstration. Even, however, in 1869, the Royal Commission on Water Supply felt themselves warranted in making the following statement:—'This purifying process is not a mere theoretical speculation; we have abundant practical evidence, which we shall hereafter refer to, of its real action on the Thames and other rivers.' Two of ourselves have of late been engaged, independently of each other, in the examination of this question, and a series of experiments under the charge of one of us is still in progress. In our next annual report we hope to give a summary of our results.

"AMMONIA AND ORGANIC MATTER.—In a tabulated form will be found recorded the quantities of free or saline ammonia present in the 318 samples of water examined. It is noteworthy that on two occasions the $\frac{1}{333}$rd of a grain per gallon, and on five occasions the $\frac{1}{500}$th of a grain per gallon were recorded. On 48 occasions the $\frac{1}{1000}$th of a grain per gallon were recorded; while 263 examinations revealed no appreciable trace of ammonia whatsoever. The proportion of samples free from recognisable ammonia amounted, in 1881, to 60·6 per cent. of the whole; in 1882, to 70·9 per cent. of the whole; and during the past year, 1883, to 82·7 per cent. of the whole.

"The actual organic matter present has been estimated by the oxygen process, and by combustion. In estimating the oxygen required, we have adopted the method described in detail by one of our number in the 'Journal of the Chemical Society' (Vol. XXXV., p. 46, 1879): while in the combustion process we have followed the lines laid

down by Frankland and Armstrong. The oxygen required to oxidize the organic matter has been estimated in seven samples daily, viz., a sample from each company's supply, and our results are summarised and arranged in our tables. The organic carbon and nitrogen have been estimated in one sample daily, and our results are also given in a table. We have in this table given also, in a companion column, the quantities of oxygen necessary to oxidize the organic matter in the same samples.

"As in our previous Annual Reports, we have appended curve diagrams, showing, in the case of each company's water, the general similarity manifested by the variations observed in the course of the year, in respect to the three items of 'organic carbon,' 'oxygen absorbed,' and 'brown tint of colour.' In another sheet we have given an additional set of curves, showing the variation in respect to the same three items undergone by what we may call mean Thames water. The three continuous curves given in this additional sheet—those for 'organic carbon' and 'oxygen absorbed' being for the three years, 1881, 1882, and 1883, and that for 'brown tint of colour' being for the last two years, 1882 and 1883 only—are the calculated mean results afforded by our examination of the water supplied by the five companies, namely, the Chelsea, West Middlesex, Lambeth, Grand Junction, and Southwark and Vauxhall Companies, taking their supply from the Thames. In these mean curves the parallelism in the variations recorded, with regard to the items in question, is more striking than in the curves giving the variations in the same items as observed in the case of the water of only one company. A glance at these continuous mean curves reveals the further fact of a successive gradual yearly diminution in the small proportion of organic matter present in the Thames-derived water supplied to the Metropolis. We have reason to think that this diminution is dependent to a considerable extent on the continuously increased efforts made by the Water Companies to improve the filtration and subsidence processes and arrangements.

The mean height of curve for each item in the several consecutive years is given in the following table:—

—	1881.	1882.	1883.
Organic Carbon . . .	0·180	0·160	0·143
Oxygen absorbed . .	0·053	0·055	0·041
Brown tint of colour .	..	21·6	17·0

"NITROGEN (AS NITRATES AND NITRITES) AND CHLORINE.—These have been estimated in daily samples of the waters, and the results are stated in our tables. The quantity of nitrogen, in the form of nitrate or nitrite, ranges from about 0·150 to 0·225 of a grain per gallon, the quantity being on the average somewhat lower in the summer and autumn than in the winter and spring quarters. Adding together the nitrogen in the form of ammonia, that in the form of organic matter, and that in the form of nitrates and nitrites, we get the total combined nitrogen of the water; from the quantity of which Dr. Frankland calculates what he calls the "previous sewage contamination" of the water, amounting in the case of the river supply of London to about one-third of that met with in the spring water supply. The quantity of chlorine amounts throughout the year to either close upon, or a little over, one grain per gallon, corresponding to about one and three-quarters of a grain per gallon of common salt.

"HARDNESS.—The degree of hardness has been estimated in a daily sample of the water, and our results are given in a table.

"The mineral matter in solution consists mainly of the carbonates of the alkaline earths, with a small quantity of sulphates, nitrates and chlorides. These salts, there is reason to believe, are beneficial rather than prejudicial to the animal economy, supplying, as they do, constituents required for the organism.

"GENERAL OBSERVATIONS.—From time to time, in our successive monthly reports, and more especially in some of those made during the past year, 1883, we have had occasion to animadvert on the . . . reports on the water supply of the metropolis addressed to the Registrar-General, and

published by him in the first number for the month of his well-known 'Weekly Returns.' We make it no reproach to the distinguished chemist responsible for these reports that he should entertain a strong objection to the river sources from which, by authority of the Legislature, and after full inquiry by Parliamentary Committees and Royal Commissions, upwards of ninety per cent. of the water supply of London is at the present time derived. In common with all who know him, we recognise his great attainments and his deservedly high scientific position. We admit, moreover, his possession of special qualifications entitling him to form, in respect to London water supply, his own independent opinion, adverse though it may be to the conclusions arrived at by the several tribunals before whom authoritative inquiries on the subject have from time to time been held. . . . To the actual analytical results set forth in his reports we do not in general take exception. . . . Despite, however, the occurrence of occasional discrepancies, to which we have not hesitated to call attention at the time, the general results of the two sets of analyses, his and ours, agree fairly well, making allowance for the fact that our samples for complete analysis are collected one on every day throughout the year, excluding Sundays and holidays; while the samples reported on by him to the Registrar-General are collected all on a single day in every month. Taking the two sets of estimations of organic carbon as an example, our own mean results for the year 1883, in grains per gallon, are given in the first column, those reported to the Registrar-General in the second column, and the differences, ranging only from six- to sixteen-thousandths of a grain per gallon, in the third column of the underneath table:—

Mean Results, 1883.	Organic Carbon.		Differences.
	Grains per gallon.		Grains per gallon.
New River Company . .	0·059	0·069	0·010
East London Company .	0·088	0·094	0·006
Thames Companies . .	0·099	0·115	0·016
	C. O. & T.	Frankland.	

"The difference in the two sets of results, even in the case of the Thames Companies' water, where it is largest, is admittedly of no practical consequence. Thus, calculating from the mean proportions of organic carbon, as given above, the mean quantity of organic matter present in the Thames-derived supply of London, for 1883, would, according to our results, just fall short of, and according to the other results would slightly exceed, a quarter of a grain per gallon ; a quantity so small as to render its absolute excess of one-tenth of a grain per gallon beyond the mean quantity present in the New River Company's supply, a matter of no consideration. It is not then to Dr. Frankland's actual results, and certainly not to his general results, that we take constant exception. We do, however, protest most strongly against the peculiar modes of statement and comparison employed by him, with obvious intent to disparage the river-water supply, and exalt the well-water supply of the metropolis. . . .

"It was explained in the report of the Royal Commission on Water Supply, that a minute proportion of organic matter, variable in amount with season, is a normal constituent of river water ; that there is no reason whatever to consider this proportion of natural organic matter as in any way prejudicial to health ; and that there is absolutely no chemical evidence to indicate that the minute proportion of organic matter present in the water supply of London is different, either in quantity or kind, from the natural organic matter of the river, as met with, for instance, at Lechlade, where the main stream of the Thames is formed. Of the typical varieties of water other than river water, resorted to for town supply, lake water is characterised, by containing, for the most part, about the same small proportion of organic matter that is present in river water ; while good spring water is characterised by containing a considerably smaller proportion of organic matter than either river water or lake water, and at the same time of containing a considerably higher proportion of total nitrogen ; . . . let us see what is implied in the statement . . . that

the amonnt of organic impurity contained in individual samples of Metropolitan water is two, three, or four times as large as a particular average amount present in the Kent Company's water ; and consider further, what is the basis of fact on which this statement reposes. In the first place, the statement clearly implies that spring water is the proper type of what river water, or at any rate of what Metropolitan water should be,—a notion entirely without foundation . . . It further suggests the notion that the wholesomeness and desirableness of different water supplies are inversely as the ascertained quantities of organic matter which they respectively contain—that a water containing two-tenths of a grain of organic matter per gallon is twice as unwholesome as a water containing only one-tenth, and a water containing one-tenth twice as unwholesome as a water containing only one-twentieth of a grain—and this irrespective of any ascertainment of the chemical nature and hygienic character of the organic matter, and irrespective of any regard to the absolute smallness, one might almost say insignificance, of even the largest quantities habitually met with. If the statement has not this implied meaning, it would seem, as we take it, to have no meaning at all. With a view to show what are the facts of the matter, we have made an abstract of the monthly results published in the Registrar-General's returns for the past year 1883, in respect to the quantities of organic carbon present in the water supplies of London, Birmingham, and Glasgow ; these results, so far as London is concerned, being, as we have already pointed out, fairly in accordance with, though somewhat higher than our own.

"The following Table shows the actual quantities of organic carbon, expressed both in parts per 100,000 and in grains per gallon, and the estimated quantities of organic matter in grains per gallon, present in the several supplies of water, as determined by monthly analyses of the London waters made by Dr. Frankland, of the Birmingham water made by Dr. Hills, and of the Glasgow water made by Dr. Mills. For the calculations giving

the figures in the second and third columns of the Table, we are responsible.

"MEANS OF MONTHLY ANALYSES, 1883.

Source.	Proprietary.	Organic Carbon.		Organic Matter.
		Parts per 100,000.	Grains per gallon.	Grains per gallon estimated.
Chalk Springs	Kent Company . . .	0·050	0·035	0·087
River Lee, and Springs .	New River Company .	0·099	0·069	0·173
River Lee .	East London Company	0·135	0·094	0·235
Loch Katrine	Glasgow Corporation .	0·143	0·100	0·250
Mixed . .	Birmingham Corporation	0·148	0·103	0·259
River Thames	The Five Companies .	0·164	0·115	0·287

"It will be seen that the organic matter of the Kent Company's spring water is under one-tenth of a grain per gallon; that the organic matter of the New River Company's water, which is to the extent of about four-fifths river water and one-fifth spring water, is considerably under two-tenths of a grain per gallon; that the organic matter of the East London Company's water, which is a river water, that of the Glasgow Corporation's water, which is a lake water, and that of the Birmingham Corporation's water, which is a mixed water, supplied in varying proportions from reservoir, stream, and well, are alike about two-and-a-half-tenths, *i.e.* a quarter of a grain per gallon; while the organic matter of the Thames companies' supply of river water is under three-tenths of a grain per gallon. It is to be noted, however, that, although the average proportion of organic matter in the Thames-derived water supplied to London is, to the extent of three- or four-hundredths of a grain per gallon, in excess of that in the Birmingham and Glasgow Corporations' supplies, this excess is entirely due to the effect of the winter floods. Comparing the results for the eight months, March to October, 1883, the proportion of organic matter in the Glasgow Corporation's supply, or 0·247 grain per gallon, is somewhat in excess of the proportion found in the Thames supply, or 0·224 grain per gallon. In view of the importance which is sometimes attached, though, as we maintain unwarrantably, to the relative variations in the

always minute proportion of organic matter present in the London supply, it is satisfactory to note that at periods of summer-heat and drought, the natural agencies at work to keep down the proportion of organic matter existing in the water of the river, are at their maximum of activity. It results, in this way, that the water supply of London is at its best at those seasons of the year when any failure in the quality of the supply might be considered likely to be of exceptionally serious import.

"The above statements, as to the particular fractions of a grain of dissolved organic matter present in a gallon of different kinds of water, serve to convey some idea of the habitual exceeding smallness of the quantity. Whether or not variations—it may be relatively large, but always falling within the limit of a very small absolute quantity per gallon—are matters of any real significance, must obviously depend on the character of the dissolved organic matter present in the different waters, or in the same water at different times. We are not unmindful of the predominant importance of this consideration; and should any charges be made impugning the wholesomeness of London water by reason of the ascertained nature of the small proportion of organic matter which it is found to contain, we shall, as we believe, be prepared to meet these charges; or undoubtedly, failing this, to admit them. But it is not from the results of any experimental investigation, as to the nature and influence of the small proportion of organic matter present in London water, that its wholesomeness is month after month by suggestion attacked. Neither is it, save in the case of a few samples collected at periods of flood, that any charge of unwholesomeness is preferred against the water by reason of the absolute quantity, or increase of quantity, of organic matter which it contains."

Note.—The author regrets that the limited space at his disposal is insufficient to admit of the numerous most interesting Tables and Diagrams which accompanied Messrs. Crookes, Odling, and Tidy's Report being inserted here. They will be found *in extenso* in the published Report.

PART II.

HISTORY AND DESCRIPTION

OF THE

LONDON WATERWORKS.

I.—THE KENT WATERWORKS.

THE Company of the Proprietors of the Kent Waterworks obtained incorporation by an Act of Parliament passed in 1809, to supply the parishes of St. Nicholas and St. Paul's Deptford; St. Alphage, Greenwich; St. Margaret, Lee; St. Mary, Lewisham; and St. Mary, Rotherhithe.

1701.—The Act empowered the Company to purchase the works and privileges of the Ravensbourne Water Works, established under royal letters patent, granted by King William the Third in the thirteenth year of his reign, for the exclusive supply of the royal manors of Sayes Court and East Greenwich, for a term of five hundred years, from the River Ravensbourne and elsewhere.

1809.—The Ravensbourne Works consisted of pumping machinery driven by a water wheel, and designed by the celebrated engineer, Smeaton, by which the water from the Ravensbourne was distributed through wooden pipes.

1811.—In 1811 the Company entered into an arrangement with the Town Commissioners of Woolwich to supply that town with water, and purchased from the Commissioners a pumping engine, together with a lease from Sir T. M. Wilson, of certain springs in the parish of Charlton, from whence it was proposed to supply the town of Woolwich. The Company thereupon applied to Parliament, and obtained a second Act, which confirmed the agreement

with the Woolwich Commissioners, and extended the Company's water limits so as to include the parishes and places of St. Mary, Woolwich; St. Nicholas, Plumstead; St. Luke, Charlton; St. Mary Magdalen, Bermondsey; and, Peckham and Peckham Rye in the parish of St. Giles, Camberwell; it also empowered them to raise a further sum of £100,000, making the total capital £250,000.

1812–1824.—The Company, acting under the advice of their consulting engineer, Mr. John Rennie, erected a pair of steam pumping engines, made by Messrs. Boulton & Watt (which are still working), and proceeded to lay down iron water mains for the supply of the district, which included the Royal Dockyards and other Government establishments at Woolwich and Deptford.

1844.—A filter bed was constructed, and the district was supplied with filtered water.

1850.—The Company obtained Parliamentary powers to raise a further sum of £100,000, which was expended in extending their mains, and in improving the Deptford Works, by the erection of a pair of 70-inch diameter cylinder Cornish pumping engines, and the construction of additional filter-beds and subsiding reservoir.

1857.—The Company sunk their first deep well in the chalk, at Deptford, which yielded an abundant supply of excellent water.

1861.—In this year the Plumstead, Woolwich and Charlton Consumers' Pure Water Company were wound up in Bankruptcy, and the works were sold by auction; they were purchased by the freeholder, Mr. Lewis Davis, who subsequently sold them to the Kent Company.

1862.—The Company obtained an Act of Parliament, with power to increase their capital to £525,000, and having been successful in obtaining further supplies from the chalk, entirely abandoned the supply of water from the river Ravensbourne.

1864.—In this year the Company obtained an Act of Parliament to amalgamate with their undertaking the North Kent Waterworks Company, incorporated by

an Act of Parliament in 1860, to supply water to the parishes of Dartford, Bexley, East Wickham, Erith, Eltham, Chislehurst and Bromley, from the River Stoneham at Crayford, but the Act was in abeyance, no works having been executed. By this Amalgamating Act the authorised capital was raised to £750,000.

1867.—The Company commenced the supply of their North Kent District, from deep wells in chalk at Shortlands and Crayford.

1868.—The Company purchased the water works of the Dartford Local Board of Health, which were constructed in 1854, but which had never been used, the Local Board having allowed their creditors to seize and sell the pumping engine on the completion of the works. In this case the Local Board obtained Parliamentary sanction for the sale of their water works to the Kent Company.

1877.—The Company, on the invitation of the Bromley Rural Sanitary Authority, applied to Parliament, and obtained powers to supply water to the Cray Valley, and the adjacent parishes, viz., Stone, Swanscombe, Darenth, Wilmington, Sutton-at-Hone, Farningham, Eynsford, North Cray, Foots Cray, St. Paul's Cray, St. Mary Cray, Orpington, Chelsfield, Farnborough, Keston, West Wickham, Hayes, and Shortlands in the parish of Beckenham. By this Act the Company's authorized capital was raised to £950,000.

1880.—The company obtained a further supply of water from a deep well sunk in the chalk in the parish of Farnborough, for the supply of their new district in the Cray Valley.

The Kent Waterworks Company have six pumping stations, situate at the following places :

Deptford.
Plumstead.
Crayford.

Shortlands.
Dover Road, Shooter's Hill.
Farnborough.

And eleven covered reservoirs, situate as under :—

Deptford, 2.
New Cross, 1.
Woolwich Common, 1.
Plumstead Common, 2.
Shooter's Hill, 1.
Greenwich Park, 1.
Chislehurst, 1.
Farnborough, 1
Dartford, 1.

The Company have entirely abandoned the supply from the River Ravensbourne, and the water is obtained wholly from deep wells in the chalk, sunk at five of their pumping stations.

The following is a description of the Company's works :—

Deptford.—The most important station is Deptford, situated on the banks of the River Ravensbourne.

There are three wells at this station, and eight pumping engines of 858 horse-power. Three of these engines are employed in lifting water from the wells, and the remainder in forcing it into the mains for the supply of the district. There are two covered reservoirs, with a joint capacity of 2,000,000 gallons. The other buildings consist of offices, cottages, workshops, stores, &c.

Plumstead.—This station has one well sunk in the chalk, and one engine of 63 horse-power, with cottage for man in charge; there are also three reservoirs, each capable of containing 200,000 gallons, which were formerly used as depositing reservoirs in connection with Dr. Clark's process for softening chalk water, which was first practically tested here, upwards of a quarter of a century ago. The apparatus which was designed to soften the water by means of cream of lime became choked with the precipitated chalk, and the process was ultimately abandoned.

Crayford.—At this station there are three wells, and three pumping engines of 186 horse-power, and a cottage for the man in charge.

Shortlands.—At this station there are two wells sunk into the chalk, and two engines of 93 horse-power, with cottage for man in charge.

Shooter's Hill.—At Dover Road, Shooter's Hill, there are a pair of horizontal engines of 47 horse-power, used for forcing the water from the Woolwich Common reservoir to the top of Shooter's Hill, and cottage for man in charge.

Farnborough.—At this station there is one well sunk in the chalk, and one engine of 120 horse-power, but the buildings are designed to contain a duplicate engine. There is a cottage for the man in charge.

New Cross.—Covered reservoir, constructed in 1874, on the top of Telegraph Hill, at an elevation of 160 feet above Ordnance datum ; it contains 1,750,000 gallons.

Woolwich Common.—Covered reservoir, containing 1,500,000 gallons, at an elevation of 250 feet above Ordnance datum.

Plumstead Common.—Two covered reservoirs, containing 850,000 gallons, at an altitude of 170 feet above Ordnance datum.

Shooter's Hill.—Covered reservoir on Constitution Hill, containing 300,000 gallons, at an altitude of 320 feet above Ordnance datum.

Greenwich Park.—A circular covered reservoir, containing 1,125,000 gallons, at an altitude of 158 feet above Ordnance datum.

Chislehurst.—A covered reservoir, containing 450,000 gallons, at an altitude of 315 feet above Ordnance datum.

Farnborough.—A covered reservoir, containing 1,400,000 gallons, at an altitude of 440 feet above Ordnance datum.

Dartford.—A circular covered reservoir, containing 370,000 gallons, at an altitude of 135 feet above Ordnance datum.

Further statistical details relating to this Company's Works will be found in *Statistics of Supply, Table No.* 1 (*ante*, page 504), and concerning its Capital, Income, Expenditure, and Profits, in *Table No.* 1A appended.

A map is also appended, shewing the parliamentary boundaries of the company, the position of the principal works and direction of the mains, the district supplied, and the area under constant supply, which are distinguished by different shadings.

As the water supplied by the Kent Company is taken wholly from the chalk, some information is subjoined (see Tables, pp. 547–552) as to its character, being analyses made by Dr. Albert J. Bernays, the analyst to the Company. The water is stated to be clear and almost free from matter of organic origin; of a perfectly blue colour when regarded in mass, of an even temperature, and pleasantly cool throughout the hot days of summer. The residue on evaporation is white, and does not change colour on ignition.

TER W

enditure on ...r each year, during a period of ten years.

SIR FRANCI... .A.

... Year).			INCOME.		
...thorised ...ng to be	Cap...	...es ...c.	Net Water Rents.	Miscellaneous Receipts (Rents of Lands, &c.)	Total Income.
			£. s. d.	£. s. d.	£. s. d.
...40			63,822 4 0	356 15 6	64,178 19 6
...20			67,437 19 4	107 2 6	67,545 1 10
...50			69,951 5 11	105 19 6	70,057 5 5
...03			74,143 18 4	118 0 6	74,261 18 10
...11			77,776 14 6	152 18 6	77,929 13 0
...50			81,283 13 5	153 0 6	81,436 13 11
...51			86,112 8 0	174 9 0	86,286 17 0
...37			90,225 12 6	186 17 0	90,412 9 6
...00			96,274 6 0	144 17 6	96,419 3 6
...25			100,463 16 4	235 17 9	100,699 14 1
			807,491 18 4	1,735 18 3	809,227 16 7

	...AGEMENT.			
... Compensation ...remises and M... ...uperannuation ...v Expenses con... ...with Maintenan...	General Establishment Charges, Stationery, Printing, &c.	Law and Parliamentary.	Official Auditor and Water Examiner.	Total Management.
	£. s. d.	£. s. d.	£. s. d.	£. s. d.
...	563 4 1	307 11 0	59 8 8	5,424 17 5
...	573 4 0	1,425 2 0	59 16 11	6,761 19 3
...	564 8 10	43 7 8	66 17 3	5,072 4 9
..	657 12 7	414 2 7	66 4 7	6,222 8 7
...	654 15 10	188 15 7	65 14 2	6,231 3 2
...	703 15 3	576 0 0	65 1 6	7,050 11 11
...	657 9 11	574 12 1	68 8 6	7,385 11 2
...	774 6 5	58 14 11	68 6 4	7,316 1 4
...	734 10 3	211 3 0	70 0 3	7,452 0 9
...	693 6 9	63 14 10	78 18 3	7,303 2 6
...	6,576 13 11	3,863 3 8	668 16 5	66,220 0 10

	Contingency or Reserve Fund.	
	Taken from	Carried to
	£. s. d.	£. s. d.
	1,500 0 0	500 0 0
	1,422 14 11	...
	...	1,000 0 0
	558 4 10	1,000 0 0
	200 19 9	1,000 0 0
	...	1,000 0 0
	354 13 7	500 0 0
	...	500 0 0
	...	350 0 0
	...	1,505 3 10
	4,036 13 1	7,355 3 10


KENT WATER WORKS
COMPANY'S DISTRICT.
1884.
DARTFORD
Swanscombe
Wilmington
R. Darenth
Darenth
Sutton at Hone
Swanley
Farningham
Eynsford
Prepared by
COLONEL SIR FRANCIS BOLTON, C.E.
Water Examiner, Metro Water Act 1871.
2
3 MILES
James Wyld 11 & 12 Charing Cross, London

DR. BERNAY'S ANALYSES.

	In terms of grains per gallon.			
	Crayford. Oct. 7, 1878.	Bath Well. Oct. 7, 1878.	Garden Well. June 26, 1878.	Shortlands. July 15, 1878.
Sodium chloride	1·20	2·73	1·50	1·51
Sodium sulphate	..	0·27	..	..
Potassium sulphate	1·11	1·23	0·17	0·12
Calcium chloride	0·68	..	0·15	0·30
Calcium sulphate	0·66	1·26	9·11	2·45
Calcium nitrate	..	..	..	0·58
Calcium carbonate	16·62	18·55	15·41	15·82
Magnesium nitrate	1·74	1·84	2·17	0·85
Magnesium carbonate	..	0·44	4·30	..
Silica	1·23	1·19	1·11	0·95
	23·24	27·51	33·92	22·58
Residue by analysis	22·96	26·92	33·12	23·27
Hardness before boiling	17·60	20·30	20·27	16·28
Hardness after boiling	2·80	5·40	6·97	7·72
Free ammonia	None	None	0·0016	None
Albuminoid ammonia	None	None	0·0078	0·002

DR. BERNAY'S ANALYSES.

Place.	Date.	Total solids.	Chlorine.	Free ammonia.	Albu-minoid ammonia.	Total hardness.	Perma-nent hardness.	Oxydized nitrogen.	Organic carbon.	Organic nitrogen.
Bath Well, Deptford . .	October 15, 1877 .	28·966	1·540	0·0014	0·0039	19·990	6·700	0·403	0·049	0·009
Bath Well	January 7, 1878. .	28·950	1·740	0·0003	0·0046	19·340	4·930	0·358	0·020	0·005
Ditto	February 23, 1878 .	28·070	1·480	0·0007	0·0025	20·640	4·880	0·339	0·024	0·010
Ditto	May 17, 1878 . .	29·200	1·780	None	0·0041	18·510	7·160	0·302	0·023	0·006
Ditto	October 25, 1878 .	26·920	1·660	None	None	20·300	5·440	0·347	0·015	0·003
Ditto	March 25, 1879 . .	27·500	1·480	0·0007	0·0028	20·300	4·950	0·393	0·018	0·003
Ditto	July 26, 1879 . .	28·800	1·660	None	0·0010	19·600	5·250	0·393	0·043	0·008
Ditto	February 13, 1880 .	28·800	1·620	0·0008	0·0018	19·600	6.100	0·351	0·037	0·006
Ditto	May 19, 1880 . .	27·510	1·440	None	0·0007	19·800	4·900	0·297	0·024	0·009
Ditto	September 2, 1880 .	27·960	1·570	None	0·0007	19·210	5·170	0·328	0·024	0·006
Ditto	January 3, 1881 . .	29·120	1·480	None	None	20·300	6·400	0·309	0·024	0·007
Ditto	September 1, 1881 .	27·790	1·700	None	0·0014	19·800	6·600	0·260	0·019	0·007
Ditto	April 1, 1882 . .	28·210	1·570	None	None	19·800	5·900	0·328	0·026	0·0077
Ditto	December 1, 1882 .	29·750	1·540	0·0004	0·0013	20·200	7·550	0·367	0·030	0·007
Ditto	August 1, 1883 . .	28·560	1·700	0·0006	0·0025	19·500	6·400	0·412	0·029	0·004
Ditto	March 11, 1884 . .	28·980	1·530	None	0·0021	18·800	5·900	0·372	0·035	0·011
Crayford	April 11, 1877 . .	25·730	1·360	0·0003	0·0011	15·990	2·230	0·427		
Ditto	January 2, 1878. .	24·330	1·317	0·0003	0·0022	17·860	3·487	0·346	0·042	0·009
Crayford, No. 2. . . .	February 23, 1878 .	22·620	1·150	0·0004	0·0052	16·740	3·860	0·320	0·024	0·006
Ditto, No. 1. . . .	February 23, 1878 .	26·850	1·230	0·0001	0·0006	17·480	4·140	0·358	0·015	0·003
Ditto	September 7, 1878 .	23·900	1·270	None	0·0007	18·600	5.600	0·379	0·012	0·003
Crayford, No. 2. . . .	September 7, 1878 .	23·170	1·440	None	None	18·300	6·100	0·330	0·010	0·002
Crayford	October 7, 1878. .	22·960	1·170	None	None	17·600	2·800	0·329		
Crayford, No. 1. . . .	February 28, 1879 .	23·280	1·110	0·0006	0·0013	18·400	3·300	0·372	0·013	0·003
Crayford, No. 2. . . .	April 25, 1879 . .	23·590	1·190	0·0006	0.001	19·300	3·500	0·365	0·020	0·003
Ditto	November 21, 1879.	23·590	1·120	0·0004	0·0011	18·300	3·400	0·348	0·030	0·009
Ditto	June 4, 1880 . .	22·540	1·180	None	0·0014	18·300	3·100	0·322	0·029	0·006
Crayford	April 1, 1881 . .	23·030	1·440	0·0011	0·0007	18·300	3·650	0·357	0·024	0·003
Ditto	January 5, 1882. .	23·380	1·110	None	0·0011	18·700	4·400	0·340	0·019	0·0024
Ditto	October 3, 1882. .	24·500	1·190	None	0·0017	18·000	2·900	0·365	0·027	0·0077
Ditto	February 3, 1883 .	23·800	1·400	0·0007	0·0014	18·600	3·800	0·335	0·029	0·009
Ditto	October 1, 83 . .	24·500	1·190	0·0010	0·0015	17·900	3·450	0·380	0·020	0·006
Garden Well, Deptford .	May 22, 1877 . .	30·198	1·440	0·0003	0·0014	19·900	6·800	0·311		

Garden Well, Deptford	November 12, 1877	31·164	1·680	0·0001	0·0021	20·000	6·880	0·326	0·073	0·014
Ditto	February 23, 1878	29·060	1·480	0·0011	0·0055	18·510	7·720	0·294	0·024	0·012
Ditto	November 4, 1878	30·870	1·480	0·0001	0·0003	21·000	6·150	0·421	0·051	0·010
Ditto	June 7, 1879	32·160	1·620	None	0·0010	19·900	6·600	0·379	0·033	0·008
Ditto	October 3, 1879	32·900	1·480	0·0001	0·0013	21·100	7·500	0·349	0·034	0·010
Ditto	March 24, 1880	29·890	1·740	None	0·0003	22·100	6·200	0·294	0·034	0·011
Ditto	October 1, 1880	30·590	1·420	None	0·0010	20·900	6·400	0·293	0·034	0·006
Ditto	July 4, 1881	32·410	1·530	None	0·0014	21·000	7·100	0·325	0·030	0·004
Ditto	January 31, 1882	33·390	1·440	None	0·0010	22·300	7·750	0·331	0·019	0·005
Ditto	November 1, 1882	30·310	1·570	None	0·0021	22·500	6·900	0·260	0·028	0·0035
Ditto	June 1, 1883	30·590	1·400	None	0·0006	20·800	6·650	0·323	0·033	0·010
Ditto	February 1, 1884	30·100	1·570	0·0006	0·0028	19·800	6·400	0·308	0·041	0·013
Orpington	August 25, 1880	21·660	0·980	0·0011	0·0017	17·200	4·850	0·498	0·038	0·013
Ditto	December 1, 1880	21·070	1·060	None	0·0014	18·600	4·700	0·477	0·027	0·003
Ditto	July 30, 1881	22·330	0·930	0·0007	0·0011	17·110	4·400	0·467	0·015	0·002
Ditto	May 1, 1882	23·380	0·980	None	0.0008	18·400	3·400	0·489	0·031	0·003
Ditto	January 1, 1883	22·260	0·980	None	0·0020	17·300	3·150	0·449	0·030	0·0056
Ditto	September 3, 1883	21·280	0·980	0·0007	0·0010	17·800	4·900	0.480	0.017	0·0050
Ditto	April 1, 1884	23·380	0·930	0·0007	0·0046	17·000	2·500	0·410	0·040	0·0012
Shortlands, Old	July 15, 1878	23·270	1·106	None	0·0011	16·460	7·720	0·259	0·019	0·006
Ditto, New	September 4, 1879	21·420	1·020	0·0001	0·0010	17·500	3·850	0·232	0·024	0·003
Ditto	May 7, 1880	21·280	0·980	0·0007	0·0011	17·300	4·000	0·274	0·019	0·003
Ditto	March 1, 1881	21·280	0·890	None	None	17·800	3·500	0·253	0·025	0·001
Ditto	October 1, 1881	22·260	0·760	None	0·0021	16·600	3·900	0·228	0·028	0·003
Ditto	June 1, 1882	22·840	0·980	None	None	17·500	3·300	0·256	0·022	0·0053
Ditto	March 1, 1883	22·400	0·980	0·0007	0·0017	17·500	3·200	0·264	0·029	0·006
Twins Well	April 2, 1878	27·820	1·570	None	0·0017	18·790	7·020	0.353	0·022	0·007
Ditto	July 1, 1880	32·760	1·620	0·0070	0·0021	20·700	7·900	0·451	0·029	0·015
Ditto	February 2, 1881	35·770	1·870	None	None	21·800	7·900	0·489	0·033	0·008
Ditto	July 1, 1882	33·600	1·700	None	0·0006	21·000	7·900	0·504	0·022	0·0035
Ditto	April 2, 1883	33·800	1·570	Trace	0·0007	21·500	7·400	0·469	0·018	0·004
Ditto	December 1, 1883	32·340	1·400	Trace	0·0034	20·000	5·800	0·490	0·045	0·018
Plumstead	February 23, 1878	34·990	2·760	None	0·0022	19·530	9·250	0·329	0·025	0·010
Ditto	January 22, 1880	36·500	3·190	0·0014	0·0032	21·300	9·800	0·319	0·041	0·008
Ditto	May 3, 1881	34·720	2·760	None	0·0004	21·800	10·500	0·421	0·041	0·009
Ditto	August 1, 1882	38·220	2·340	0·001	0·0017	21·100	10·150	0·398	0·029	0·008
Ditto	May 2, 1883	37·940	2·380	Trace	0·0011	23.300	11·400	0·563	0·025	0·011
Ditto	January 2, 1884	35·140	2·870	0·0007	0·0021	20·800	10·150	0·443	0·048	0·010

DR. BERNAY'S ANALYSES.

Knowing now something of the constitution of these several waters, it is interesting to note the quality of the water as supplied at the Deptford Bridge Police Station. This water varies, of course, according to the well-water most in use at the time of pumping; but, with the information conveyed above, the variations will be quite intelligible.

Place.	Date.	Total solids.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Total hardness.	Permanent hardness.	Oxydized nitrogen.	Organic carbon.	Organic nitrogen.
Deptford Bridge Police Station	April 3, 1877	30·786	1·480	None	0·0007	17·760	5·77	0·355		
Ditto Ditto	May 1, 1877	30·630	1·610	0·0007	0·0010	18·130	5·76	0·332		
Ditto Ditto	June 1, 1877	32·858	1·590	None	0·0007	20·270	6·88	0·414		
Ditto Ditto	July 2, 1877	30·410	1·700	None	0·0018	18·600	6·09	0·339		
Ditto Ditto	August 8, 1877	30·702	1·750	0·0003	0·00056	19·440	6·83	0·329		
Ditto Ditto	October 1, 1877	29·620	1·540	0·0008	0·0022	20·270	5·02	0·420		
Ditto Ditto	November 2, 1877	30·970	1·490	0·0004	0·0031	19·340	6·60	0·350		
Ditto Ditto	December 1, 1877	29·526	1·617	0·00014	0·0007	19·900	6.56	0·298		
Ditto Ditto	January 2, 1878	29·624	1·530	0·00014	0·0024	19·440	6·04	0·378		
Ditto Ditto	February 1, 1878	32·120	1·570	0·00014	0·0008	18·770	7·35	0·343		
Ditto Ditto	March 1, 1878	31·080	1·570	0·0030	0·0017	19·600	5·39	0·327		
Ditto Ditto	April 1, 1878	30·350	1·480	0·0006	0·0024	18·970	6·51	0·322		
Ditto Ditto	May 1, 1878	29·680	1·440	None	0·0043	19·720	4·93	0·401		
Ditto Ditto	June 2, 1878	33·390	1·620	None	0·0025	20·270	7·72	0·411		
Ditto Ditto	July 1, 1878	26·810	1·530	None	0·0015	19·620	5·35	0·326		
Ditto Ditto	August 2, 1878	31·780	1·620	None	0·0007	20·180	6·70	0·358		
Ditto Ditto	September 2, 1878	28·030	1·620	None	0·0004	18·880	4·51	0·360		
Ditto Ditto	October 1, 1878	28·140	1·570	None	0·0007	20·600	4·500	0·346		
Ditto Ditto	November 1, 1878	21·460	0·860	None	None	17·800	4·500	0·246		
Ditto Ditto	December 2, 1878	31·850	1·400	None	0·0004	20·200	6·050	0·410		

Deptford Bridge Police Station	January 1, 1879	28·700	1·530	0·0003	0·0020	20·100	5·150	0·333		
	February 1, 1879	30·600	1·570	0·0003	0·0017	22·000	6·350	0·337		
Ditto Ditto	March 1, 1879	27·580	1·660	0·0004	0·0015	20·500	6·000	0.350		
Ditto Ditto	April 1, 1879	29·850	1·660	None	0·0006	22·300	7·150	0·328		
Ditto Ditto	May 1, 1879	30·030	1·620	None	0·0028	20·100	6·950	0·356		
Ditto Ditto	June 2, 1879	32·510	1·400	0·0008	0·0022	20·300	6·650	0·449		
Ditto Ditto	July 1, 1879	32·720	1·700	None	0·0001	20·900	7·650	0·399		
Ditto Ditto	August 1, 1879	28·660	1·700	None	0·0007	20·300	5·150	0·403		
Ditto Ditto	September 1, 1879	29·010	1·530	None	0·0017	20·100	5·750	0·428		
Ditto Ditto	November 1, 1879	31·930	1·530	None	0·0007	20·000	5·900	0·351		
Ditto Ditto	December 1, 1879	27·860	1·780	0·0013	None	20·700	5·900	0·375		
Ditto Ditto	January 4, 1880	29·400	1·620	None	None	21·000	5·500	0·267		
Ditto Ditto	February 2, 1880	30·410	1·690	0·0014	0·0013	22·400	8·350	0·356		
Ditto Ditto	March 3, 1880	31·290	1·700	0·0006	0·0015	23·300	9·000	0·375		
Ditto Ditto	April 2, 1880	31·190	1·700	None	0·0010	21·800	7·150	0·353		
Ditto Ditto	May 3, 1880	30·800	1·830	0·0008	0·0006	22·000	6·800	0·350		
Ditto Ditto	June 2, 1880	29·890	1·700	0·0001	0·0006	20·000	6·900	0·290		
Ditto Ditto	July 1, 1880	29·960	1·480	None	0·0007	20·300	7·000	0·327		
Ditto Ditto	August 27, 1880	23·480	1·190	None	None	17·020	4·380	0·227		
Ditto Ditto	September 1, 1880	21·730	1·150	None	None	16·100	3·660	0·266		
Ditto Ditto	October 1, 1880	23·520	1·230	None	0·0007	18·300	4·570	0·275		
Ditto Ditto	November 3, 1880	23·130	1·400	0·0010	0·0011	19·200	5·300	0·305		
Ditto Ditto	December 1, 1880	33·040	1·700	0·0049	0·0011	22·900	6·900	0·482		
Ditto Ditto	January 1, 1881	28·980	1·700	0·0042	None	20·900	6·700	0·326	0·031	0·006
Ditto Ditto	February 1, 1881	35·980	1·610	None	None	21·300	7·650	0·490	0·036	0·011
Ditto Ditto	March 1, 1881	31·010	1·600	None	0·0010	21·300	7·100	0·369	0·031	0·007
Ditto Ditto	April 1, 1881	32·830	1·150	0·0007	0·0004	21·300	7·050	0·282	0·025	0·007
Ditto Ditto	May 3, 1881	30·240	1·480	0·0004	0·0014	21·700	6·700	0·319	0·033	0·010
Ditto Ditto	June 1, 1881	32·480	1·270	0·0004	0·0007	21·800	7·400	0·340	0·034	0·010
Ditto Ditto	July 1, 1881	34·650	1·660	0·0003	0·0017	20·900	7·300	0·341	0·036	0·011
Ditto Ditto	August 1, 1881	28·420	1·530	None	0·0018	20·800	7·900	0·298	0·021	0·006
Ditto Ditto	September 1, 1881	29·610	1·660	0·0028	0·0028	19·400	8·000	0·284	0·027	0·010
Ditto Ditto	October 1, 1881	30·310	1·700	0·0006	0·0028	20·800	8·000	0·358	0·036	0·011
Ditto Ditto	November 1, 1881	29·890	1·480	None	0·0014	21·300	7·600	0·333	0·034	0·010
Ditto Ditto	December 1, 1881	31·710	1·480	None	0·0011	21·000	8·000	0·313	0·022	0·0043

DR. BERNAY'S ANALYSES.

Place.		Date.	Total solids.	Chlorine.	Free ammonia.	Albuminoid ammonia.	Total hardness.	Permanent hardness.	Oxydized nitrogen.	Organic carbon.	Organic nitrogen.
Deptford Bridge Police Station		January 1, 1882	26·600	1·020	0·0007	0·0014	19·800	6·150	0·258	0·017	0·0035
		February 1, 1882	31·710	1·570	None	None	21·500	7·150	0·378	0·027	0·010
Ditto	Ditto	March 1, 1882	31·470	1·440	None	0·0018	22·300	8·900	0·315	0·029	0·007
Ditto	Ditto	April 1, 1882	30·100	1·150	None	0·0021	21·600	6·900	0·332	0·028	0·010
Ditto	Ditto	May 1, 1882	29·540	1·660	None	0·0014	21·300	7·000	0·356	0·029	0·008
Ditto	Ditto	June 1, 1882	29·540	1·480	None	0·0011	20·800	6·900	0·332	0·031	0·0054
Ditto	Ditto	July 1, 1882	31·500	1·570	None	0·0010	20·000	6·650	0·351	0·032	0·007
Ditto	Ditto	August 1, 1882	30·240	1·480	0·0010	None	18·300	6·400	0·309	0·031	0·0053
Ditto	Ditto	October 1, 1882	30·380	1·360	0·0001	0·0014	20·200	5·150	0·318	0·031	0·011
Ditto	Ditto	November 1, 1882	30·800	1·320	0·0006	0·0018	21·300	5·650	0·374	0·027	0·007
Ditto	Ditto	December 1, 1882	30·660	1·680	None	0·0007	20·300	6·400	0·335	0.039	0.012
Ditto	Ditto	January 1, 1883	30·800	1·680	None	0·0010	20·500	5·650	0·339	0·044	0·012
Ditto	Ditto	February 1, 1883	28·560	1·610	None	0·0014	20·100	7·150	0·306	0·033	0·009
Ditto	Ditto	March 1, 1883	30·660	1·480	None	0·0021	21·700	7·050	0·333	0·030	0·008
Ditto	Ditto	April 2, 1883	30·800	1·480	0·0008	0·0022	21·300	6·900	0·323	0·031	0·006
Ditto	Ditto	May 1, 1883	33·600	1·530	None	0·0014	21·800	9·400	0·385	0·035	0·014
Ditto	Ditto	June 1, 1883	29·960	1·530	0·0007	0·0020	20·100	6·250	0·361	0·031	0·009
Ditto	Ditto	July 2, 1883	32·620	1·610	0·0003	0·0017	21·800	8·050	0·388	0·022	0·006
Ditto	Ditto	July 31, 1883	30·520	1·270	0·0010	0·0017	19·800	6·650	0·364	0·030	0·008
Ditto	Ditto	September 3, 1883	30·380	1·480	0·0020	0·0022	20·100	7·250	0·323	0·038	0·015
Ditto	Ditto	October 1, 1883	29·260	1·440	0·0021	0·0018	20.800	5·650	0·333	0·032	0·010
Ditto	Ditto	November 1, 1883	29·540	1·400	None	0·0010	20·300	7·400	0·314	0·030	0·008
Ditto	Ditto	December 1, 1883	29·680	1·480	0·0011	0·0014	20·000	5·900	0·340	0·034	0·010
Ditto	Ditto	December 31, 1883	29·680	1·190	0·0014	0·0018	20·300	5·900	0·358	0·043	0·009
Ditto	Ditto	February 1, 1884	29·820	1·480	0·0008	0·0007	19·000	7·000	0·331	0·020	0·005
Ditto	Ditto	March 1, 1884	29·400	1·480	None	0·0004	19·300	7·400	0·342	0·015	0·003
Ditto	Ditto	April 1, 1884	28·980	1·400	0·0001	0·0041	18·800	6·650	0·364	0·033	0·010

II.—THE NEW RIVER.

AMONG all the institutions of "still-increasing" London, there is not one which has caused greater interest than that "antient foundation," the New River, which was inaugurated over two centuries and a half ago, namely, on the 29th day of September, 1613, in the reign of King James I.

The ceremonial observed at the inauguration of this great work, which had taken five years to complete, and had cost a vast sum of money, is pleasingly narrated by an old chronicler :—

"On the Michaelmasse-day in anno 1613, being the day when Sir Thomas Myddelton, brother of the said Hugh Myddelton, was elected Lord Maior of London for the yeere ensuing, in the afternoone of the same daye, Sir John Swinnerton, knt., and Lord Maior of London, accompanied with the said Sir Thomas, Sir Henry Montague, knt., Recorder of London, and many of the worthy aldomen, rode to see the Cisterne, and first issuing of the water thereinto, which was performend in this manner :—

"A troope of labourers, to the number of sixty or more, well apparelled, and wearing green Monmouth caps, all alike, carryed spades, shovels, pickaxes, and such like instruments of labourious imployment, marching after drummes twice and thrice about the Cisterne, presented themselves before the mount, where the Lord Maior, Aldermen, and a worthy company beside, stood to behold them ; and one man (in behalf of all the rest) delivered this speech :—

"Long have we labour'd, long desir'd, and pray'd
For this great work's perfection; and by th'ayd
Of Heav'n, and good men's wishes, 'tis at length
Happily conquer'd by cost, art, and strength,
And after five yeeres' deare expence in dayes,
Travaile, and payne, beside the infinite wayes
Of malice, envy, false suggestions,
Able to daunt the spirits of mighty ones
In wealth and courage. This a work so rare
Onely by *one man's* industry, cost, and care,
Is brought to blest effect, so much withstood;
His onely ayme the Citie's generall good.
And where (before) many injust complaints,
Enviously seated, caused oft restraints,
Stops and great crosses, to our master's charge.
And the work's hindrance, Favour now at large
Spreads herself open to him, and commends
To admiration, both his paines and ends,
(The King's most gracious love). Perfection draws
Favour from Princes, and from all applause.
Then, Worthy Magistrates, to whose content,
(Next to the State) all this great care was bent;
And for the publicke good (which grace requires),
Your loves and furtherance chiefly, he desires,
To cherish these proceedings, which may give
Courage to some that may hereafter live
To practice deedes of goodnesse and of fame,
And gladly light their actions by his name.

"At which words the flood gates flew open, the streame ranne gallantly into the Cisterne, drummes and trumpets sounding in a triumphall manner, and a brave peale of chambers gave full issue to the intended entertainment."

George Bickman, in the year 1772, published an engraving, entitled "Sir Hugh Myddelton's glory, or the first issuing of the waters into the New River head, before the aldermen, Recorder, and a worthy company who stood to behold it." This engraving (a specimen of which may be seen in the New River Company's annexe) represents the waters flowing into a round reservoir, about which are grouped various persons, conspicuous amongst whom is the Lord Mayor on a white horse. On his left is Sir Hugh Myddelton, on the right is his brother, between Sir Thomas and Sir Henry Montague, the Recorder.

The following is appended to the engraving :—

"Clerk of the works, reach me the book, to show
How many arts from which a labour flow.
First here's the overseer, this try'd man
An ancient Soldier, and an Artizan.
The Clerk next him, Mathematician
The Master of the Timber Work takes place,
Next after these the Measurer, in like case
Bricklayer and Engineer, and after these
The Borer and the Pavier, then it shows.
The Labourers, next keeper of Amwell Head ;
The Walkers next so all their names are read.
Yet these but parcels of six hundred more,
That at one time have been employed before.
Yet these in Sight and all the rest will say
That all the week they had their ready pay.
Now for the Fruits then : Flow forth precious spring,
So long and dearly sought for, and now bring
Comfort to all that love thee ; loudly sing,
And with thy chrystal murmurs strook together,
Bid all thy true well wishers welcome hither."

Such was the inauguration of the Company's works, which, after a lapse of 271 years, still continue to supply the City, and North London, with water.

Thanks to the preservation of the records of the time of Charles I., it is possible to give a summary of the History of the New River, from a document which was some years ago discovered among the State papers.

It is not only interesting, but very valuable, being an official description of the undertaking, as given before the judges, and a curious review of one of the earliest troubles the Company had to endure.

While quoting the document in its original phraseology, as far as possible, those numerous repetitions which appear in all legal writings are avoided :—

"Whereas, by virtue of two severall Acts of Parliament, the one made in the third yeare of the raigne of the late King James of ffamous memorie (the first), and the other in the fourteenth yeare of the saide late kings raigne of this realme of England, The Maior, Comonalitie, and Citizens of London, and their successors, had free libertie

given unto them, and were enabled to bring a ffresh streame of runing water to the North parts of the said Citty of London from the springs of Chadwell and Amwell, and other springs in the Countie of Hertford, and not far distant from the said springs.

"And the Said Maior, Comonalitie, and Citizens, considering the greate charge and expense of the saide worke and doubttinge much losse might befall upon the Chamber of the said Cittie, in case the said worke should not succeede well and prove beneficall, did thereupon forbeare at their common charge to undertake the saide worke, soe as the same lay long neglected, and unlike by them to be p'formed. And that Sir Hugh Myddelton, Baronet, deceased, late Citizen and Gouldsmith of London, beinge willing of his owne private charge to undertake the saide worke to that purpose, did make offer to the then Lord Maior, Aldermen, and Comons of the said Citty assembled at a Comon Councell holden within the said Citty on the xxviiith day of March, in the seaventh yeare of the raigne of the saide King James, to undertake the saide worke and to performe (at his owne charges) whatever was or should be necessarie and convenient to be doone and performed on the parte and behalfe of the said Citizens, which saide offer was willinglie accepted and imbraced, by the then Lord Maior, Aldermen and Comon Councell assembled.

"And that thereupon, they, by their indenture under their Comon Seale bearinge date the xxviiith day of March, in the nineth yeare of the raigne of the saide King James, made between the saide Maior, Aldermen, and Citizens, of the one part, and the said Sir Hugh Myddelton, of the other parte, did make and appoint the saide Sir Hugh Myddelton, his heirs and assignes, their true and lawful attorneys, deputies and agents, to carry out the saide worke, confirming to him the whole of the proffit, comoditie, and advantage that should be raysed and gained by the saide River New Cutt and streame, and the water and benefit of the water that might come or be conveyed thereby, and free libertie of laying and conveying the pipes for the

currency and passage of water," through the districts authorized.

"And the saide Sir Hugh Myddelton did begin to convey the saide springs in a new channel or river towards the saide Citty of London, and proceeded soe farre therein as that he brought the saide water divers miles towards the saide citty. But finding the charge of the saide worke to be greater, and the difficulties thereabouts to be more than he expected, the saide Sir Hugh Myddelton thought fitt to ioyne unto himselfe for helpe therein some other persons of qualitie which were willinge to adventure and ioyne with him in contribucon towarde the charge of the saide worke, whereupon divers persons of qualitie became Adventurers with the saide Sir Hugh Myddelton in the saide worke, and made severall agreements to pay and contribute, and it was agreed that they should have and receive severallie to them and their heirs ratable shares or parts of the proffits to growe and arise out of the saide worke, according to the proporcon of their severall disbursements, and after they had proceeded soe farre that it was found to be feasible, the saide late King James, considering that the saide worke would be of greate use and benefitt into the saide Citty, and beinge willinge to vouchsafe his ayd by indenture under the greate Seale of England, bearing date the second of May of the tenth yeare of his rayne ower England, did agree to beare and paye the one halfe and moitie of the charges disbursed, and to be expended in perfecting the saide worke, on the condition of payment to him of half the profits, &c.

"And for the better effecting and continuing the saide watercourse, and to make the same usefull for the saide Citty, it was necessary to make and have a greate Store Pond or Poole, whereunto the saide New Cut might emptie itselfe, and thence be derived in pipes unto the saide Citty in some convenient place nere the saide Citty.

"The adventurers at their greater costs and expenses did dig and make one greate and large Store Pond or Poole to receive and keepe the water running in, and cominge from

the saide New River, and walled the same roundabout, with a faire brick wall, and at the entry thereof, erected and built a fitt and convenient dwelling house of brick, as a residence for the custodian of the same pondes, and they also made two other waste Pondes adjoining to the saide store Ponde to receive and keep the surplusage of the water of the saide New River when the Store Ponde was full."

A work of considerable difficulty had yet to be accomplished with the New River, namely the distribution of the water to the various parts of the metropolis in which it was needed. "This was done," says an old writer, "with all possible diligence, by pipes of elme and lead, but for the most part elme, from which pipes many high streats and lanes within the city are plentifully served."

In Hughson's 'History of London,' is the copy of a lease for twenty-one years, granted in 1616, by Hugh Myddelton, to a citizen and his wife, "of a pipe or quill of half inch bore, for the service of their yarde and kitchine by means of two Swan necked cocks," in consideration of a certain sum to be paid yearly.

Those who lived at a distance from the mains were supplied by the water carriers, who carried the water in wooden pails slung from a yoke across their shoulders, and attracted notice by crying aloud, "Any New River water here."

By letters patent, dated 21st day of June in the seventeenth year of the said King James, A.D. 1619, Myddelton and the other adventurers therein named were incorporated by the name of the Governor and Company of the New River, brought from Chadwell and Amwell to London, and various rights and privileges were therein conceded to the said adventurers, "after which at a Court holden by the said Governor and Companie at Sergeants Inne in Ffleete Streate, London, on the 2nd day of November, Anno Domini, 1619," the company by agreement granted to Sir Robert Naunton and others on behalf of the king "the one moyetie or half of the clear profits of the said water

works," and at subsequents courts, orders were made for the carrying on of the business.

About the year 1631 the affairs of the New River Company became much embarrassed, and King Charles I., who then held the Royal moitie, was therefore led to dispose of his interest in the concern, lest it might prove burdensome to his Exchequer.

Sir Hugh Myddelton "obtained the other moytie in fee farme from his Majestie at and under the rent of 500 li (£500) per annum," executing an indenture accordingly, and the King covenanted that he would not grant or assign his interest, but that it should for ever continue annexed to the Crown, under the name of "King's Clogg." This payment is still annually made to the Royal exchequer.

Hugh Myddelton, while working some Welsh mines, had acquired a good knowledge of levelling, embanking, etc. Hence, after he came to London, the proposal of the City to bring up the water from Chadwell did not appear so visionary a scheme to him as it did to them.

After undertaking the work, he soon found that he had no easy task to construct the aqueduct, some thirty-eight miles in length, not to mention the remarkable opposition he met with on the route from landowners and others. He had expended a very large sum of money, when want of funds compelled him to apply to King James ; accordingly the King advanced to Sir Hugh Myddelton, between the years 1612 and 1616, an amount equal to one-half the then cost of the construction of the work.

The formation of the river occupied five years, although seven years had been allowed to Sir Hugh for its completion. The exertion made is shown by the circumstance that as many as 600 men were employed for some time in the undertaking.

Sir Hugh Myddelton, by his will, dated November 20th, 1631, and proved a month later, leaves all his parts or shares in the New River to his "lovinge wife Dame Elizabeth," and after her death a part or share to each of his three sons and two daughters, and the sixth share to

the Goldsmiths Company, of which he was a member, in trust for their poor brethren. He declared in the same deed that one-half of the waterworks was divided into thirty-six shares, of which thirteen belonged to himself; of these thirteen shares, six were disposed of as described above, and the remainder passed into his general estate.

It may here be stated that in 1582 Peter Morrys, a Dutchman (the inventor of a process for raising water by means of a tidal wheel), had come to London and introduced his invention—that "the Lord Maior and a goodly companie" had ridden down to London Bridge to observe his experiments, and had seen him throw the water over St. Magnus' steeple—and that after this the City of London granted him a lease of one of the arches of old London Bridge for 500 years.

The old water-wheel erected by Morrys worked on till about 1822.

The London Bridge Waterworks * were then absorbed by the New River Company, who undertook to supply all citizens whom the Dutchman's wheel had served, with New River water, and to secure the then dividend to the original proprietors of the London Bridge Waterworks for 260 years, the unexpired term of the original lease of 500 years, granted as stated above.

Acts of Parliament were obtained for various special purposes affecting the Company in 1738, 1739, 1767, 1779, 1805, 1822, and 1830. It was under the last named of these Acts that the two large impounding reservoirs at Stoke Newington were made.

In 1852 an Act was passed, wherein the expenditure of the Company in carrying out and completing their works then in existence was stated to be over £1,519,958. The same Act authorised many improvements and works, such as straightening the river, new reservoirs, filter-beds, engine premises, etc.

The New River takes its rise at Chadwell Spring, about

* For a further description of these Works, see p. 634, *infra*.

one mile beyond Ware, in Hertfordshire. It is joined at a short distance below its source by a branch cut, bringing water from the river Lee. The additional quantity of water thus received is regulated and limited by the action of a floating gauge, placed at the upper end of the cut.

The length of the New River was originally forty miles, but this has been reduced to twenty-eight miles by straightening the channel at various places, where, formerly, it followed the windings of a contour of the ground. At such places the stream is now carried in direct lines by earthen embankments, masonry aqueducts, or tunnel. Along its course are numerous wells with pumping machinery, for raising water from the large subterranean reservoirs of the chalk strata.

The following is a descriptive list of the various stations at which water is raised from wells, stored, filtered, pumped for distribution, or served from covered reservoirs

Broad Mead.—A deep chalk well, with pumping engine of sixteen horse-power.

Amwell End.—A deep chalk well, with pumping engine of fifty-horse power.

Amwell Hill.—A deep chalk well, with pumping engines of seventy-five horse power.

Amwell Marsh.—A deep chalk well, with engine house, in which are now being erected pumping engines of seventy horse-power.

Rye Common.—A deep chalk well, with pumping engines of two hundred horse-power.

Hoddesdon.—A deep chalk well, with pumping engine of fifty horse-power.

Broxbourne.—A deep chalk well, now in process of being sunk.

Turnford.—A deep chalk well, with pumping engines of one hundred and fifty horse-power.

Cheshunt.—A deep chalk well, with pumping engine of twenty horse-power, and two storage reservoirs, having a total area of eighteen and a half acres and a total available capacity of thirty-nine million gallons.

Hoe Lane.—A deep chalk well, with pumping engines of one hundred and seventy horse-power.

Highfield.—A deep chalk well, over which an engine house is now being built for the reception of pumping engines of two hundred and ten horse-power.

Hornsey.—Subsiding reservoirs, having a joint area of eight acres and a total available capacity of eight million five hundred thousand gallons, with eight filter-beds, having a joint area of five and a quarter acres, and pumping engines of four hundred and forty horse-power.

Campsbourne, Hornsey.—A deep chalk well, now in process of being sunk.

Stoke Newington.—Two subsiding reservoirs, having a joint area of forty-two and a half acres and a total available capacity of ninety million gallons, nine filter-beds, having a joint area of nine acres, pumping engines of one thousand and eighty horse-power, and shops for repair of machinery, etc.

New River Head, Clerkenwell.—Subsiding reservoir, having an area of three quarters of an acre; three filter-beds, having a joint area of two and a quarter acres; pumping engines of two hundred horse-power, offices, store-houses, testing and stamping shop, meter-repairing, plumbers', blacksmiths' and carpenters' workshops, stabling, etc.

Claremont Square, Pentonville.—A covered service reservoir, having a capacity of three million five hundred thousand gallons.

Hampstead Road.—A deep chalk well, not now used.

Camden Road.—An open service reservoir for unfiltered water, having a capacity of nine hundred thousand gallons. Water is supplied from this reservoir for street watering and trade purposes only.

Hampstead Heath.—A deep chalk well not now used, and five ponds, having a joint area of eleven acres, and a total available capacity of ten million five hundred thousand gallons. These ponds store the surface water of the

surrounding district, and are used only for street watering and trade purposes.

Hampstead.—A covered service reservoir, having a capacity of five hundred thousand gallons.

Kentish Town.—A deep well, not now used.

Maiden Lane.—Two covered service reservoirs, having a total capacity of fifteen million gallons.

Highgate.—Eight ponds, having a joint area of nineteen acres, and a total available capacity of nineteen million five hundred thousand gallons. These ponds store the surface water of the surrounding district, and are used only for street watering and trade purposes.

Highgate Hill.—A covered service reservoir, having a capacity of one million gallons.

Hornsey Lane.—A covered service reservoir, having a capacity of three million gallons, with pumping engines of seventy-five horse-power.

Crouch Hill.—Two covered service reservoirs, having a total capacity of twelve million gallons.

Tottenham.—Pumping engines of one hundred and twenty-five horse-power, for raising water from the river Lee. These engines have not been used for more than twenty years.

Betstile, New Southgate.—A deep chalk well, with pumping engines of twenty-four horse-power.

Bourne Hill, Edmonton.—A covered service reservoir, having a capacity of one million five hundred thousand gallons.

Southgate.—A covered service reservoir, having a capacity of one million gallons.

During the summer of last year, as much as thirty million gallons of water per day were pumped to service reservoirs. For the whole of that year, the *average* quantity daily pumped was over twenty-five million gallons; while the *total* supply (including water which was served *without* pumping), amounted on an average to 28,369,711 gallons per day. The Company supply a population of more than a million persons, living in about one hundred and forty

thousand houses. For this service, about seven hundred and seventy-two miles of cast iron pipes, (varying in diameter from thirty-six inches to three inches) have been provided.

As an illustration of the manner in which the New River Company have sought to provide for public requirements, attention may be drawn to the fact that more money has been expended in improvements, &c., during the last twenty years than was spent in the constructions of the previous two hundred and fifty years.

Further statistical details relating to this Company's Works will be found in *Statistics of Supply*, *Table No.* 2 (*ante*, facing page 504), and concerning its Capital, Income, Expenditure, and Profits, in *Table No.* 2A appended.

A map is also appended, shewing the parliamentary boundaries of the Company, the position of the principal works, and direction of the mains, the district supplied, and the area under constant supply, which are distinguished by different shadings.

RIVER CO

ıditure on Mainteṛ each year, during a period of ten years.

EL SIR FRANCIS |, F.C.A.

Year).			INCOME.		
rised g to	Capital expend	ses, es, nd	Net Water Rents.	Miscellaneous Receipts, Rent of Lands, &c.	Total Income.
	£.	d.	£. s. d.	£. s. d.	£. s. d.
	2,702,30	6	297,891 4 5	10,000 3 9	307,897 8 2
	2,727,94	2	318,745 6 1	10,525 10 11	329,270 17 0
	2,792,20	6	331,978 16 4	10,302 4 8	342,281 1 0
	2,892,80	4	347,631 14 10	8,350 3 4	355,981 18 2
	2,980,21	0	362,668 4 11	8,655 5 9	371,323 10 8
	3,030,13	1	377,029 14 6	10,498 17 0	387,528 11 6
	3,082,87	3	385,043 2 7	11,786 16 4	396,829 18 11
	3,132,50	0	400,816 0 5	10,893 8 4	411,709 8 9
	3,188,17	6	416,848 9 0	8,667 9 10	425,515 18 10
	3,256,07	8	427,723 14 9	8,895 12 2	436,619 6 11
	...	0	3,666,376 7 10	98,581 12 1	3,764,957 19 11

GEMENT.					
ises, Insurance npensations, annuation and connected with aintenance.	Tot on	General ablishment Charges.	Law and Parliamentary, connected with Management.	Official Auditor and Water Examiner.	Total Expenditure on Management.
£. s. d.		£. s. d.	£. s. d.	£. s. d.	£. s. d.
484 4 7		543 12 11	3,856 1 4	388 19 8	30,677 7 8
482 8 9		1684 18 4	440 13 6	275 1 0	29,707 8 0
086 8 5		494 0 8	1,686 16 11	305 7 2	31,526 19 3
246 10 3		1574 14 4	1,159 7 11	301 14 0	30,075 2 11
927 6 9		1659 16 1	1,449 13 3	304 17 8	30,804 0 1
317 15 11		1021 17 2	4,483 13 2	307 2 1	37,095 13 0
972 3 4		1509 12 7	143 8 0	308 4 10	34,738 5 9
381 0 3		1158 6 6	2,515 7 8	307 1 9	37,051 15 9
980 9 4		1369 4 3	479 0 6	312 1 6	35,610 17 5
819 17 2		1170 18 7	1,177 16 3	348 7 3	39,043 18 3
698 4 9	1,0	87 1 5	17,391 18 6	3,158 16 11	336,331 8 1

ce and ns, less &c.		r.
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To face page 564.

James Wyld 11 & 12 Charing Cross London

III.—THE EAST LONDON WATERWORKS.

THE Shadwell Waterworks supplied a considerable portion of East London with water, commencing in 1669.

The first Act of Parliament was obtained in 1691; and Thomas Neale, Esq., was appointed "Governor."

In 1747 an Act was passed empowering George Montgomerie and others to complete an undertaking for supplying Stratford, West Ham, Bow, &c., with water; and a pumping station was erected on a branch of the river Lee, the pumps being worked by a water wheel. These works passed out of the possession of the East London Waterworks Company at Christmas, 1883.

In 1807 an Act was passed empowering the London Dock Company to purchase the West Ham Waterworks, and the rights of the proprietors were transferred and vested in the London Dock Company.

In 1807 an Act was passed establishing the East London Waterworks Company, and in the following year an Act was passed empowering the East London Waterworks Company to purchase the Shadwell and West Ham Waterworks from the London Dock Company. The amount of capital authorised by the acts of 1807 and 1808 was £380,000.

The Company constructed at Old Ford settling reservoirs, having an area of about 11 acres. A service reservoir was also made at Mile End. The necessary pumping machinery was erected, and the first engines, named the "Twins," are still at work and in very good condition.

In the year 1809 10,739 houses were in supply, and the gross revenue was £10,051 11*s.* 0*d.* In 1819 the number of houses was 29,926, and the gross revenue £34,370 4*s.* 9*d.*

The basis of charge was according to the number of rooms in each house, the size of the rooms, and the situation of the house. The average rate per house was then £1 2*s.* 11¼*d.* per annum. At the present time it is somewhat higher. The average supply of water per house in 1809 was 54 gallons per day. In 1820, this had risen to 135 gallons. The mean elevation at which water was delivered was 120 feet, and a number of houses even then received a constant supply. Mr. Robert Wright, in his evidence before the Select Committee on the Supply of Water to the Metropolis in 1821, stated that he had frequently seen water thrown over the highest houses in Shoreditch by the East London Waterworks Company.

From the establishment of the Company to the time of the Select Committee in 1821, the average dividend was 2¼ per cent. per annum. In 1813, 1814, 1820 and 1821 no dividend was paid.

In 1827 the number of houses supplied was 42,207, and the gross income £45,442 19*s.* 5*d.*

In 1829 the Company purchased the Hackney Waterworks and the Lee Bridge Mills, and also obtained an Act empowering them to remove their intake from Old Ford to Lee Bridge.

Other Acts were passed in 1852 and 1853, fixing the capital and defining the district the Company are authorised to supply. By the latter Act authority was obtained to make several new cuts in connection with the River Lee, for improving the quality of the water, and to construct large impounding reservoirs at Walthamstow, and filter-beds at Lee Bridge, as also to make an intercepting cut or canal on the westerly side of the River Lee from Tottenham to a distance beyond Ponders End, for preventing any polluted water entering the river above the Company's intake.

In 1854 and 1862 Acts were passed for increasing the capital of the Company.

In 1867, an Act was passed to enable the Company to construct a covered service reservoir in Finsbury Park, and also to establish works at Sunbury and Hanworth, for

supplying Thames water to their district. All these works were carried out as they now exist.

In the same year a separate Act was obtained for increasing the number of reservoirs at Walthamstow, and filter-beds at Lee Bridge. The Company were also bound to discontinue the use of and to fill up the open reservoirs at Old Ford, and to cease using the open canal connecting the open reservoirs with the works at Lee Bridge.

The company have nine stations, viz.,

Old Ford.
Lee Bridge.
Walthamstow.
Chingford.
Woodford.
Buckhurst Hill.
Hornsey Wood.
Sunbury.
Hanworth.

The Company have three distinct sources of supply—from the River Lee, the intake being at Chingford ; from deep wells in the chalk at Walthamstow and Chingford, and from the River Thames at Sunbury. The latter is a supplementary supply, and is only in use when the water from the Lee and from the wells in the chalk is insufficient for the district.

1. *Old Ford.* At this station the filtered water from Lee Bridge is conveyed by 4-feet cast iron pipes into a covered reservoir containing 1,500,000 gallons, from which 6 engines, with an aggregate of 800 horse-power, pump the water into the district.

It was at this station that the first Cornish pumping engine was erected in London by the late Mr. Wicksteed, a former engineer of the Company. This engine was named "Cornish," and it effected an enormous saving in the cost of pumping as compared with the then existing

engines. This engine is still in use, and doing very good duty.

2. *Lee Bridge.* At this station the water from the reservoirs at Walthamstow is received into filter-beds, of which there are 25 with a joint area of 24 acres.

The filtering medium consists of 2 feet of sand, 6 inches of hoggin, and 1 foot of coarse gravel, making a total depth of filtering material of 3 feet, 6 inches.

The district is partly supplied from this station by seven engines of 1050 horse-power. Water power is also used for pumping purposes.

The other buildings consist of stores, workshops, cottages, &c.

2. *Walthamstow.* The water is taken from the River Lee at Chingford, and conveyed by two large brick culverts into the high level reservoirs. The low level reservoirs are supplied from the high level, or from the Company's canal.

The reservoirs are eight in number, and have an area of 220 acres. There are well wooded islands in most of the reservoirs, and the effect is exceedingly picturesque. The total capacity is nearly 900,000,000 gallons, of which 600,000,000 are available to supply the filter-beds at Lee Bridge by gravitation. Here, with so extensive an area for atmospheric influence, oxidation in the most beneficial form takes place, as the water is always passed through these enormous reservoirs before being sent to Lee Bridge for final filtration.

A well with bore-hole is here sunk into the chalk, the depth from surface to bottom of bore being 405 feet; the chalk water is pumped into the district, the motive power being a turbine, capable of giving out seventy horse-power. The fall actuating the turbine is obtained by intercepting the water passing from the high level reservoirs to the canal leading to the Lee Bridge works.

4. *Chingford.* The intake from the River Lee is situated a short distance above Chingford Mill. A well and bore-hole have been sunk into the chalk, and the water so

obtained will be pumped by water power into the district. There is an auxiliary compound steam-engine, for use in case of floods when water power is unavailable.

5. *Woodford.* These works were completed in 1877, and consist of two covered service reservoirs, containing 3,000,000 gallons, and two engines of sixty horse-power each. The level of water in the reservoirs is 171 feet above Ordnance datum ; and water is pumped from these into the higher districts at Woodford, Buckhurst Hill, Loughton, Chigwell, and Walthamstow. The other buildings consist of cottages, store-rooms, &c.

6. *Buckhurst Hill.* A water tower was erected at Buckhurst Hill in 1879. The tank holds 70,000 gallons, and its altitude is 328 feet above Ordnance datum. The immediate neighbourhood and Loughton are supplied from the tower.

7. *Hornsey Wood.* The Hornsey Wood reservoir is situate in Finsbury Park, and is covered. A large number of lawn-tennis courts have been made on the top, and the public have free access over it. It contains 5,000,000 gallons, and is connected with the Thames supply as also with the Lee Bridge Works. Its altitude is 142 feet above Ordnance datum.

8. *Sunbury.* The intake is on the north bank of the Thames above Sunbury Lock. There are two engines, of seventy-five horse-power each, which force the water to the Hanworth Works, about two miles away.

9. *Hanworth.* The water from Sunbury is received into an open reservoir, containing about 5,000,000 gallons, from whence it flows on to six filter-beds, which have a joint area of five acres, and are of similar construction to those at Lee Bridge.

The water, after being filtered, passes into two covered reservoirs, having a joint capacity of 2,500,000 gallons.

There are three engines, having an aggregate of 600 horse-power, which force the water over a tall stand-pipe and through about nineteen miles of 36 inch main, to the Hornsey Wood Reservoir in Finsbury Park, and from

thence it gravitates over the whole of the East London Waterworks Company's middle level district.

The chimney at Hanworth is nearly 250 feet in height, and forms a conspicuous object in the landscape.

The East London Waterworks Company laid iron pipes at the commencement of this century, in lieu of the old wooden ones formerly used by the Shadwell and West Ham Companies. The wooden ones were totally inadequate to withstand the pressure. Many large mains then laid are in use now and in good condition. The largest then put down was 36 inches in diameter.

Provision for fires was made by means of wooden plugs, driven into a specially prepared pipe, having a socket looking upwards. The fixing of these has been discontinued for some time past. Hydrants, with sluice valve, are now used instead, and those fixed inside the Metropolitan area have the standard screw thread of the Metropolitan Fire Brigade; those in West Ham, Leyton, Walthamstow, Woodford, Buckhurst Hill, Loughton and the remainder of the Company's district have a thread specially cut to suit the various local fire brigades.

Further statistical details relating to this Company's Works will be found in *Statistics of Supply*, *Table No.* 3 (*ante*, facing page 504), and concerning its Capital, Income, Expenditure, and Profits in *Table No.* 3A, appended.

A map is also appended, shewing the parliamentary boundaries of the Company, the position of the principal works, and direction of the mains, the district supplied, and the area under constant supply, which are distinguished by different shadings.

...ON WATERW...

...penditure on Mainte... year, during a period of ten years.

...EL SIR FRANCIS B...

...ch Year).		INCOME.		
...thorised ...ining to ...rd.	Capital expen...	...et Water Rents.	Miscellaneous Receipts, Rents of Lands, &c.	Total Income.
		£. s. d.	£. s. d.	£. s. d.
...40	1,883,13...	...66,074 4 5	3,859 16 6	169,934 0 11
...40	1,895,34...	...72,782 2 8	4,142 13 4	176,924 16 0
...40	1,898,08...	...75,382 7 11	4,419 9 6	179,801 17 5
...60	1,913,31...	...83,816 13 1	3,902 18 9	187,719 11 10
...40	1,942,13...	...91,119 7 10	3,883 4 0	195,002 11 10
...40	1,967,58...	...200,543 6 6	3,886 18 9	204,430 5 3
...90	2,027,91...	...200,022 7 7	3,919 16 0	203,942 3 7
	2,064,54...	...211,975 14 10	3,971 8 0	215,947 2 10
...00	2,104,03...	...223,181 14 0	3,879 5 3	227,060 19 3
...00	2,146,12...	...230,452 15 6	3,881 2 10	234,333 18 4
	...	...955,350 14 4	39,746 12 11	1,995,097 7 3

...r.

...mpensations, ...ises and Mills; ...annuations and ...w Expenses ...nnected with ...aintenance.	Total E... on Ma...	...ent ...	Law and Parliamentary, including re-adjustment of Boundary Line.	Official Auditor and Water Examiner.	Total Expenditure on Management.
	£.	d.	£. s. d.	£. s. d.	£. s. d.
...	58,62...	5	1,059 12 2	193 3 4	13,363 1 2
...	58,61...	11	401 19 0	191 19 5	12,833 5 7
...	57,88...	9	952 5 3	211 6 0	13,971 8 0
...	58,87...	11	1,901 18 0	205 6 4	15,547 1 6
...	63,49...	10	578 17 1	201 11 7	15,589 2 3
...	66,16...	1	1,792 2 9	204 7 11	15,745 18 9
...	73,61...	3	935 15 1	202 7 3	16,191 1 8
...	72,84...	9	4,703 5 9	203 4 6	19,581 8 6
...	77,37...	8	3,431 7 7	202 1 6	19,380 8 2
...	73,99...	0	1,080 1 9	224 10 11	17,922 11 1
...	661,49...	7	16,837 4 5	2,039 18 9	160,125 6 8

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LONDON

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Company

IV.—THE SOUTHWARK AND VAUXHALL WATERWORKS.

THE formation of the Southwark and Vauxhall Water Company was effected in 1845, by the amalgamation of two Companies, the Southwark Water Company and the Vauxhall Waterworks Company.

The Borough of Southwark was originally supplied with water by an undertaking called the London Bridge Waterworks, which was established for the supply of water to the Metropolis in the earlier part of the year 1582. In 1767 the Company obtained a lease from the City, and erected two water wheels, in the fifth arch from the North side and the second from the South, under old London Bridge. These wheels remained in operation until the construction of the new Bridge was contemplated, when the removal of the wheels having become inevitable, the Company merged into the New River Company.

About 1771, an Association, not established by Act of Parliament, was formed for providing a portion of the Borough of Southwark with water, the supply for which was obtained from a pond at St. Mary Overies. After several changes of proprietorship the property came into the sole possession of Mr. Edwards Vaughan in 1820, and in 1822 that gentleman made an agreement with the New River Company to purchase from that Company for the sum of £26,550 the whole portion of the London Bridge Waterworks lying South of the Thames, which he then called the Southwark Water Company.

Mr. Edwards Vaughan died in 1833, and in 1834 an Act of Parliament was obtained giving to his representatives the power of selling the Southwark Waterworks.

In the early part of 1839 a Company was formed to purchase the works, and in June of that year the conveyance was finally signed, the Company becoming liable for all expenses from the 1st June, 1839. The purchase money for the property was £41,000, including £16,550 due to the New River Company, as the unpaid portion of the sum agreed to be paid to them by Mr. Edwards Vaughan. At the time of completing the conveyance there was paid accordingly £24,450 to the representatives of Mr. Edwards Vaughan, and to the New River Company £6,550, it being agreed that the remaining portion of £10,000 due to them should be paid off by annual instalments of £2,500.

When the new Company took possession of the works, the supply of water was furnished in bulk by the Lambeth Company, for an annual payment of £2,400. This state of things could clearly only be considered as provisional, both because it left the existence of the Company, or at least their security, dependent on the will of another Company, who might at any time, by giving nine months' notice, withdraw the assistance they afforded, and because the Company's Act of Incorporation of 1834 expressly directed that the supply of water should be taken from the neighbourhood of Battersea and filtered previous to delivery. The Company therefore proceeded at once to acquire the necessary land at Battersea for the construction of the contemplated works, and in 1841 they were in possession of 18 acres of freehold land, on which had been constructed a depositing reservoir of 7 acres, divided into two parts, with entrance and double sluices from the Thames. Also a filter-bed of 2¼ acres; and an engine-house containing, first, an engine of 45 horse-power that had been previously used at Southwark for the supply to that district, and, secondly, a Cornish engine of 160 horse-power, with boiler house, and four Cornish boilers. A standpipe 130 feet high had also been erected, and these works were connected with the district supplied by the Company by an iron main 20 inches in diameter, and 2¼ miles long.

At this time portions of South London were also supplied

by an association called the Vauxhall Waterworks Company, originally established on the 6th October, 1804, under the title of the South London Waterworks, an application for powers to construct the works, &c., being made to Parliament in the ensuing session. Under this Act powers were obtained to raise capital to the amount of £80,000, and so favourable was public opinion to the project, that the shares speedily rose to a premium of 50 or 60 per cent. On the 24th June, 1807, the first supply of water was afforded to the public.

Unfortunately for the Company, six weeks later, on the morning of the 6th August, their engine-house and the wooden tank used as a reservoir were destroyed by fire, damage being done to the amount of £2,720.

Temporary arrangements had then to be made for the supply of the fifty-six customers then on the books of the Company, and by the aid of a two horse-power engine this was effected. The directors believing that the fire was caused maliciously, offered a reward of 200 guineas for the detection of the offenders.

At this time only £90 was paid on each share, and although the whole of the income was applied to the improvement and extension of the works, it proved to be inadequate to the requirements of the Company, and therefore in June, 1813, another Act was obtained, empowering the Company to raise a further sum of £80,000.

Owing to the expense of replacing the decayed wooden pipes with iron, and erecting a 40 horse-power engine, engine house and boiler, it became necessary in 1823 to borrow of the Commissioners under the Exchequer Bill Loan Act, a sum of £7,000. In 1825, to meet a further expenditure on account of the pipe plant, 150 new shares were created and added to the capital, these shares being taken by the proprietors at £90 each.

At this time the Company received the river water from a watercourse, or brook, called at Brixton the "Washway," flowing into the Thames at Vauxhall. Repeated disputes arose concerning the jurisdiction over this brook, the banks

of which, for want of the necessary repairs, were falling into a most dilapidated state in those places where they were artificially supported.

In 1827-28 auxiliary works at Cumberland Gardens, adjoining the foot of Vauxhall Bridge, were constructed, consisting of a 20 horse-power engine, removed from the works at Kennington Lane, where it had been lying disused since the destruction of the works by the fire in August, 1807; also a 42-inch tunnel leading into the centre of the river, terminating 8 feet below low-water mark. By this means a portion of the water was pumped direct from the river into the reservoir at Kennington Lane; but the bulk of the supply was taken direct from the channel at Vauxhall Creek.

Principally owing to the statements made before a Committee of the House of Commons in 1830, and partly on account of the effect of the removal of old London Bridge and the increasing accumulations in Vauxhall Creek, which the Commissioners of Sewers refused to remove, this supply from Vauxhall Creek at neap tides rapidly decreased in quantity, and became deteriorated in quality. The Company therefore decided to lay down a large iron tunnel to communicate with the inlet laid beneath the bed of the river, and thus convey the river water directly into the Kennington Lane Works. This was completed and taken into use on the 15th September, 1832. This tunnel consisted of a range of iron pipes 48 inches in diameter, laid at a depth of 20 feet for a considerable distance. It probably exceeded in dimensions any previously employed for similar purposes in the Metropolis.

At this period the engine at Cumberland Gardens was used at low water and neap tides to pump the water from the River Thames into the reservoirs at Kennington Lane; but at spring tides the water flowed naturally into the reservoirs, and filled them to a depth of 9 feet.

In Kennington Lane the Company possessed about five acres of land, on which two circular reservoirs were constructed, about 145 feet in diameter, one having a depth of

15 feet 6 inches and the other 12 feet. Both were lined with brick, and the bottom sloped gradually from the circumference to the centre. It was a circumstance in favour of the Company that the source of supply was now situated at the centre of the river, at that time generally pure and bright; but in addition to this, two years later, in 1834, the reservoirs at Kennington Lane were altered and improved, and a new square reservoir and filter-bed were constructed.

In June, 1834, the Company obtained an Act, to remove several difficulties under which they had hitherto laboured, and to extend their limits of supply. This Act also altered the designation of the Company to the Vauxhall Company, in order to avoid mistakes, which were frequently being made by the public in confounding the "Vauxhall" (hitherto called the South London) with the "Lambeth" and the "Southwark" Companies.

In 1840 the south reservoir at Kennington was raised 4 feet, and provision made for erecting an additional engine at Cumberland Gardens. But owing to the general difficulties in which the Company became involved, partly in consequence of the active competition with other Companies, and partly through the large outlay occasioned by the substitution of iron for wooden pipes, with the erection of more powerful pumping machinery, a committee of proprietors was appointed at a general meeting in December, 1841, to investigate the concerns of the Company. This enquiry resulted in a meeting held in March, 1842, at which a new Board of Directors was appointed.

In the Session of 1843 two rival schemes were formulated for the supply of this Company's district. One was however abandoned without proceeding to Parliament, and the other was subsequently successfully opposed before the standing Orders Committee, and the Bill thrown out.

An extension was made at this time in the tunnel pipes in the bed of the river, which were carried out about 70 feet further, so that a supply of water was rendered available at all times of the tide.

At a general meeting in December, 1843, it was first proposed to amalgamate the Vauxhall with the Southwark Company, a committee being appointed to take the matter into consideration, and at a meeting held in November, 1844, it was resolved to take the necessary steps to apply to Parliament for powers to amalgamate the property of the two Companies. These powers were obtained without opposition in the Session of 1845, and the final amalgamation of the two Companies took place on the 1st October of that year, the new Company being called the Southwark and Vauxhall Waterworks Company.

Immediately after the Companies were amalgamated, additional land was bought at Battersea, in order that the whole of the works might be concentrated at one station.

The extension of these works consisted of a large new filter-bed, deposit reservoir, new engine and boiler houses and chimney-shaft, together with the construction of a special engine for lifting the water from the river into the depositing reservoir; also the removal, alteration, and re-erection of the Cornish engine, formerly belonging to the Vauxhall Company, from the works at Cumberland Gardens to the works of the united Company at Battersea.

A new main, twenty-seven inches in diameter, was also laid from these works to Kennington.

In 1846 a new standpipe was erected, 145 feet high, and the old standpipe raised to the same level; a large culvert was also laid into the river for the supply of the lifting engine, for which purpose a number of the cast iron pipes, formerly laid by the Vauxhall Company, for the supply of their Kennington Lane Works, were utilised.

The works at Cumberland Gardens and Kennington Lane, hitherto used for the supply of the Vauxhall Company's district, having now become unnecessary, the engines were finally stopped on the 22nd February, 1847, and the land, together with the engines, buildings, and machinery thereupon (excepting the large Cornish engine), was sold to the Phœnix Gas Company, possession being taken by that company on March 25th, 1847.

In 1850, the culvert through which the supply was obtained from the river was extended further into the bed of the stream, in order to admit of the water required for the supply being taken in only during such portion of the ebb tide as permitted the reflux past the site of the Company's works of the whole of the London drainage.

In 1851 two shallow experimental wells were sunk on land adjoining the reservoirs, for the purpose of ascertaining if an additional supply of water from springs that were believed to exist could be obtained. Although water was found in abundance, it was not sufficiently soft to be suitable for the general purposes of the Company's supply.

At a general meeting held on the 5th November, 1851, it was decided, subject to Parliamentary sanction being obtained, to change the source of supply from Battersea to a point on the Thames a short distance above the village of Hampton. This Act was obtained in the Session of 1852. In order, however, to facilitate the passing of the Act, the Company consented, with the sanction of the Select Committee to whom the Bill was referred, to enter into arrangements for the supply of the Parish of Putney.

Immediately after the Bill had received the Royal assent, contracts were entered into for the intended new works. These consisted at Hampton of the erection of engine and boiler houses, chimney-shaft, and standpipe tower, two reservoirs, dwelling houses, &c.; also six boilers and two direct-acting engines, with cylinder sixty-six inches in diameter, and ten feet stroke, with pump-plunger forty-two inches diameter; also a main thirty-six inches diameter and 23,000 yards long, to convey the water from the new works at Hampton to the existing works at Battersea.

At Battersea the alterations consisted in the removal of the lifting-engine, and the erection in its place of a direct-acting Cornish engine with a seventy-inch cyclinder, ten feet stroke, and pump-plunger thirty-three inches diameter; also two additional boilers thirty feet long. A new filter-

bed was constructed, and the engine and boiler houses were extended.

As, in addition to obtaining water above tidal influence, the Act of 1852 contemplated, subject to certain conditions, the Company giving a constant supply to the district, it was deemed desirable to obtain land situated at an elevation capable of commanding the highest portions of the district in order to allow of the construction of service reservoirs thereon. Accordingly, in November, 1854, fourteen acres of land were purchased at Nunhead, Peckham, which came into the Company's possession on the 25th March, 1855.

In the Session of 1855 the Company obtained an Act of Parliament enabling them to raise additional capital to the amount of £288,500.

The new works being sufficiently advanced, on Friday the 26th July, 1855, the first supply of water was pumped from Hampton to Battersea, where preparations had been made to give full effect to the improved quality of the supply. The deposit reservoirs had been cleaned out, and new sand added to the filtering bed.

Owing to the rapid increase in the number of supplies, it was found necessary to further increase the pumping power at Battersea, and in July, 1856, contracts were entered into for the erection of a new boiler-house, chimney-shaft, coal store, &c ; also for an engine with cylinder of 112 inches, and pump plunger of fifty inches diameter, having each a stroke of ten feet ; together with five additional boilers, a new standpipe, and the heightening and connecting of the old standpipe thereto.

That the improvements made up to this date, not only in the works of the Southwark and Vauxhall, but of all the Metropolitan Water Companies, were well and faithfully executed, satisfactory testimony was born in the report to the President of the General Board of Health laid before Parliament in 1856, the Inspector stating, "that the new works have not in fact been limited to what a bare

compliance with the provisions of the Act of 1852 would have fulfilled; measures have been adopted for the general improvement of the supplies which evince a proper anxiety on the part of the companies in the discharge of the duties of their position towards the public."

In October, 1856, the first application was made for the supply of water to houses in Wimbledon, and in November, of the same year, the Company decided to erect the necessary engine power and lay the requisite mains, in order to give the supply in accordance with the request.

In June, 1857, by an agreement entered into with the Lambeth Company, it was arranged that the Southwark and Vauxhall Company should supply the upper portion of Wimbledon, and on the 17th September, 1857, the first supply was afforded.

In October, 1858, the 112-inch cylinder engine commenced work, and in the same month instructions were given for the erection of three additional boilers at Battersea.

In 1859 the erection of a river wall in front of the Battersea works was commenced.

In order to guard against any possible interruption in the supply of the Wimbledon and Roehampton districts, the Company commenced in June, 1860, the erection of a duplicate 55-inch engine at the Battersea works.

In August of the same year, consequent on an application from the Parish of Richmond, negotiations were commenced with the then existing Richmond Water Company for the purchase of their works, pipes, &c., and the supply was transferred to the Southwark Company on September 29th, 1861.

In the early part of 1862, the Company commenced the erection of an additional engine at the Hampton works. This engine has a cylinder 70 inches in diameter, and a stroke of 10 feet, with a pump plunger 42 inches in diameter. Three additional boilers were also provided.

In consequence of the new line of the London, Chatham,

and Dover Railway passing through a portion of the Company's filters at Battersea, the Company, after suitable arrangements had been made with the Railway Company, constructed, in 1862, two additional filter-beds.

In 1864 six additional boilers were added to the nineteen hitherto at work, and a new dwelling and lodge erected.

In 1866 a new main, 15 inches in diameter, was laid to supply the higher portions of the Peckham district. With the view of providing for the rapid increase in the number of the Company's supplies, the construction of additional works at Hampton was commenced in 1867. These consisted of a river wall, deposit reservoir, three filter beds, and the erection of two engines and eleven boilers, the engines having cylinders 80 inches in diameter, and 10-feet stroke. A new main, 30 inches in diameter, from Hampton to Wandsworth, was also laid in this year.

In 1869 the Company acquired additional land at Battersea, and constructed thereon a depositing reservoir capable of containing 27,000,000 gallons, which, together with the extension works at Hampton, was completed and taken into use in the spring of 1870.

In 1871 the northern depositing reservoir at Battersea was converted into a filter-bed; the floors of the other reservoirs were covered with concrete, and the slopes with brickwork and concrete.

In the same year, in order to provide for the requirements of the Act of 1871, additional works were commenced at Peckham. These consisted of four covered service reservoirs, capable of containing about 18,000,000 gallons, two being situated at a height of 150 feet above Ordnance datum, and two at 200 feet; also the erection of two direct-acting Cornish engines and four boilers, the engines having cylinders 36 inches in diameter, and a stroke of 9 feet. The 30-inch main was also extended from Wandsworth to the new reservoirs, and new 20-inch, 16-inch, and 12-inch distributing mains were laid to connect the works with the various districts to be supplied.

In 1873 further land was acquired at Hampton to provide for future extensions of the works.

In 1874 an additional boiler-house, containing four boilers and a chimney-shaft, was erected at the Hampton old works.

In 1876 the filters at Battersea were renewed throughout, and two of the large beds sub-divided.

In 1878 an additional 30-inch main with flexible joints was laid across the River Thames at Richmond, in order to make this main of uniform diameter throughout its whole length.

In 1881 the Company commenced sinking a deep well to the chalk on land they had acquired at Streatham, and these works are now in progress.

In 1883 three chimney-shafts at the Battersea works, which would have required extensive repairs, were taken down and replaced with a single shaft, capable of giving an ample draught to the whole of the boilers at this station. In the same year four of the oldest boilers were removed and replaced with three Lancashire boilers.

The present source of supply, situation of works, and extent of the district supplied, is as follows:—

The water supplied by this Company is derived from the Thames (from which river it is, by an agreement with the Thames Conservancy, authorised to take 20,000,000 gallons per diem), the intakes being situated on the north side of the river, above Hampton.

There are two sets of works drawing supply from the Thames into subsiding reservoirs.

The upper works send water into the Battersea works, where the same is there filtered, and pumped into the London district.

At the lower works the water is filtered at Hampton, and from the two sets of works the district is supplied by the Company.

This district is contained within an area comprising the following parishes and places:—

All Saints, Wandsworth; St. Mary, Battersea; Holy

Trinity, Balham; St. Mary, Lambeth; Brixton; Stockwell; St. Mary, Newington; Kennington; St. Mary Magdalen, Bermondsey; St. Mary, Rotherhithe; St. Giles, Camberwell; Walworth; Christchurch; St. George the Martyr, Southwark; St. Saviour's, Southwark; St. Thomas, Southwark; St. John, Southwark; St. Olave's, Southwark; St. Nicholas, Southwark; St. Paul's, Deptford; Peckham; Peckham Rye; Dulwich; Putney; Mortlake; Barnes; Ham; Petersham; Kew.

The estimated number of inhabitants and houses supplied by this Company at the end of 1883 was as follows:—

Inhabitants	749,345.
Houses	100,154.

Constant supply is now being rapidly extended in the Company's district, and there are at the present time over 10,000 houses so supplied, principally in the Parishes of:—

St. George the Martyr; St. Mary, Newington; St. Giles, Camberwell; and Lambeth.

The average daily supply, as calculated for the year 1883, was 27·23 gallons per head, and 202 gallons per house. The maximum quantity per head was 30·16, and the minimum 23·56 gallons; the total *average* daily supply *for the year* being 20,270,738 gallons, about 18 per cent. of which quantity was used for other than domestic purposes.

The present stations of the Company are situated as follows:—

1. Hampton Works.
2. Battersea Works.
3. Nunhead Works.
4. Streatham Works (in course of construction).
5. Sumner Street (offices).

HAMPTON WORKS.

These works are divided by the Lower Sunbury Road into two portions, that on the north for supplying unfiltered water to the Battersea works, and that on the south and east for filtering and supplying direct into a portion of the district.

The works consist in the first place of masonry and iron inlet from the river, crossing under the road, and supplying two deposit reservoirs, each with an area of upwards of an acre.

The reservoirs are simple excavations, the slopes being lined with coarse gravel, the excavated earth having been utilised for raising the general surface of the ground above the danger of floods. The water flows into tanks provided with suitable screens and sluices, and thence through cast-iron pipes into the engine wells.

The engines and boiler-houses, coal-store, &c., are buildings constructed of brickwork faced with white Suffolk bricks with cement dressings, iron roofs, and slated. The engines are all contained in one house, and are single-acting Bull engines, delivering over a standpipe placed in a tower which also contains one of the chimney shafts.

The two Bull engines (Nos. 1 & 2), which were those originally erected, have cylinders of 66 inches diameter, with 10 feet stroke, and pump hole of 39 inches diameter, pumping 516 gallons per stroke, the average speed being about 6·6 strokes per minute. The other (or No. 3) engine is larger, and was erected in 1864; the diameter of the cylinder is 70 inches, the stroke 10 feet, the diameter of the pump pole 42 inches, and the discharge 600 gallons per stroke, with an average speed of about 7·25 strokes per minute. These engines are supplied with steam by thirteen boilers. The latter are single-flued Cornish boilers, 28 feet long, 5 feet 9 inches diameter, with 3 feet 6 inches flues. Nine of these are situated to the eastward of the engine-house, the chimney-shaft of the flue from these occupying the angle of the stand-pipe tower; the other four are to the south of the engine-house, with a separate shaft.

A store and a workshop are attached to the building, where repairs to machinery, &c., are effected.

The pumps all discharge into a stand-pipe 140 feet high, from whence the water flows through a 36-inch main to Battersea.

Two cottages are attached to these works, for the residence of the managers, &c.

These works are wholly independent, and are connected in no way with those on the eastern side of the road, being solely for supplying water to the Battersea works.

The works on the eastern side are raised well above the height of the highest floods, and consist of a river wall the whole length of the frontage, the intake being part of that already described.

The wall, which is of great strength, is constructed of concrete in blue lias lime, and is faced on the river side, below the bed of the same, with brickwork 14 inches and 9 inches thick. The whole is surmounted with a Bramley fall coping.

The landing-place for coals is at the lower end of the river wall, and has a heavy coping, being also at a lower level to enable the carts to back against the barges for unloading coals, &c.

The inlet tank at the upper end is 36 feet long, and is for the entire length provided with cast iron gratings, with $\frac{1}{4}$ of an inch openings. The water flows from this inlet into the subsiding reservoir, which has a water area of about two and a half acres. Across the western end of this there is a screen which has been formed of a double wall of piles, the space between being filled in with fine hoggin. From this reservoir the water flows through pipes provided with valves into the filter-beds.

These are three in number, each having a sand area of about an acre, and each capable of filtering $2\frac{3}{4}$ million gallons, at the rate of 5 inches per hour, the works having been constructed to supply 7,000,000 gallons of filtered water per diem.

These filter-beds are surrounded and separated by puddle walls, carried down into and incorporated with the clay, so as to prevent the infiltration of either land or river water.

The filter-beds are lined on the bottoms and sides with six inches of concrete, the latter being lined in addition

with brick on edge paving to a depth of one foot below the filtering surface.

The filtering medium consists of 12 inches of boulders, six inches of coarse gravel, six inches of fine gravel, twelve inches of hoggin, and 2 feet 6 inches of sand.

The water is let on to the beds through 30-inch cast iron pipes, also arranged to drain the surface when necessary.

Four sand-washers, with drains, &c., are erected for washing the filtering medium from time to time.

The filtered water is collected on the bottom by means of side drains, formed of perforated bricks, into the main culvert, and thence conveyed through a 4-feet circular brick culvert to the engine wells.

The buildings are faced with Suffolk bricks and cement dressings, to correspond as nearly as possible with the old works.

There are two single-acting Cornish beam-engines, with the beams supported on cast iron entablature and columns.

The cylinders are 80 inches in diameter with 10 feet stroke.

The pumps are 24¾ inches diameter, double acting, having same stroke, and deliver through a loaded valve equal to a lift of 210 feet, giving 371 gallons per minute each, and working upon an average 8·5 strokes per minute, delivering into the 30-inch main.

The boilers, which are situated on the east side of the engine house, are eleven in number, each 28 feet in length, 5 feet 10½ inches in diameter, with single tube 3 feet 6 inches.

On the eastern side of the boiler house is the coal store, capable of containing from four to five hundred tons, and on the east of this, again, are two stores.

The chimney shaft is detached from the building. It is 110 feet high, and 5 feet square inside the flue.

A cottage, containing three rooms on one floor, is constructed near the gate for the accommodation of the gate-keeper.

At Hampton, on the Sunbury Road, the Company have some 31 acres of freehold land, on which is now being

constructed a system of collecting works, in order to render available the large supply of water found in the gravel beds adjoining the river, so as to enable the Company to draw a supply therefrom at times when the river is in flood.

BATTERSEA WORKS.

These works were originally constructed for taking in the tidal waters of the Thames; and when, in 1854, the intake was removed to Hampton, they were retained as the works of distribution to the district, and have been added to from time to time, till they have attained their present extent.

The total area of ground owned by the Company at this station is about 50 acres, of which 30 acres are occupied by the works, the rest having been obtained for future extensions as opportunities have offered.

The water is received from Hampton into two reservoirs, one of which is bisected by a dividing wall of concrete nearly up to the top water-line, so that they may be practically taken as three. When full they contain 46,000,000 gallons, or about two days' supply. They are lined with concrete, and the slopes with brick on edge paving in addition.

Originally there were six filter-beds, one of which is divided into three parts, and another into two, so that there are practically nine. The total area occupied by these beds is $11\frac{3}{10}$ acres.

They are all enclosed with puddle, and the insides lined with concrete, some with brick on edge up the slopes, others having in addition gravel up portions of the same.

The filtering medium is 5 feet 6 inches in thickness, and consists of coarse gravel 9 inches, fine gravel 9 inches, hoggin 1 foot, and sand 3 feet.

The water is let on to these beds from the storage reservoirs, and is conducted to the engine wells by means of cast iron pipes, one of 4 feet diameter, and the other of about 27 inches diameter.

For the purpose of draining some of these beds, and emptying the northern reservoirs, a centrifugal pump with boiler has been erected over the main drain tank.

The engine-house contains five single-acting Cornish beam-engines, and one Bull-engine.

They are of the following dimensions, viz. :—

	Beam Engines.					Bull.
	1.	2.	3.	4.	5.	6.
Diameter of cylinder . .	55"	55"	68"	64"	112"	70"
Length of stroke . . .	8'·0"	8'·0"	10'·0"	9'·6"	10'·0"	10'·0"
Average number of strokes per minute	11·46	11·71	7·24	7·54	6·93	6·27
Diameter of pump pole .	15⅝"	15"	33"	33"	50"	33"
No. of gallons per stroke .	110	100	360	340	820	360
Lift of water in feet . .	320 feet		170 feet			
Description of plunger .	Double acting		Single acting			

Nos. 1 and 2 of the above engines deliver through loaded valves at a lift of say 320 feet, for the supply of Wimbledon and the other high districts, and Nos. 3 to 6 over a stand-pipe of 170 feet. These are supplied with steam by 24 single-flued Cornish boilers, half being 32 feet long, and the others 28 feet.

Adjoining the boiler-house is a large coal-store, and other stores, one of which contains water-testing offices, &c. There is a gasholder outside.

Between these buildings and the river are the stores, smith's-shop, fitting-shop, and stable.

The fitting-shop is provided with an engine not only for driving the machinery, but also for pumping water for sand-washing purposes.

There are five sand-washers connected with the necessary drains, and deposit tanks for the sand.

The works are faced on the river side with a substantial

river wall, constructed of concrete, and faced with brickwork, the whole being surmounted with a substantial stone-coping. The entire length of this frontage exceeds 1400 feet.

A brick wall separates the works from the high road.

A large cottage, containing nine rooms, is constructed for the residence of the manager, and an entrance lodge of 4 rooms for the gatekeeper. In addition there are three detached stores, one for filter-cleaning tools, &c., one for the coal wheelers, and the other for valves and other apparatus used in the district.

There is also a brick experimental tank for testing, &c.

NUNHEAD WORKS.

These are purely distributory works, and consist of four covered reservoirs arranged in pairs, the top water-line of the lower ones being about 146 feet above Ordnance datum, and the upper ones about 186 feet above the same.

The water is raised from the lower to the upper reservoirs by means of two Bull engines, over a standpipe 50 feet high.

The sizes of the engines are as follows :—

Diameter of cylinders, 36 inches ; length of stroke, 9 feet ; diameter of pump hole, 24 inches.

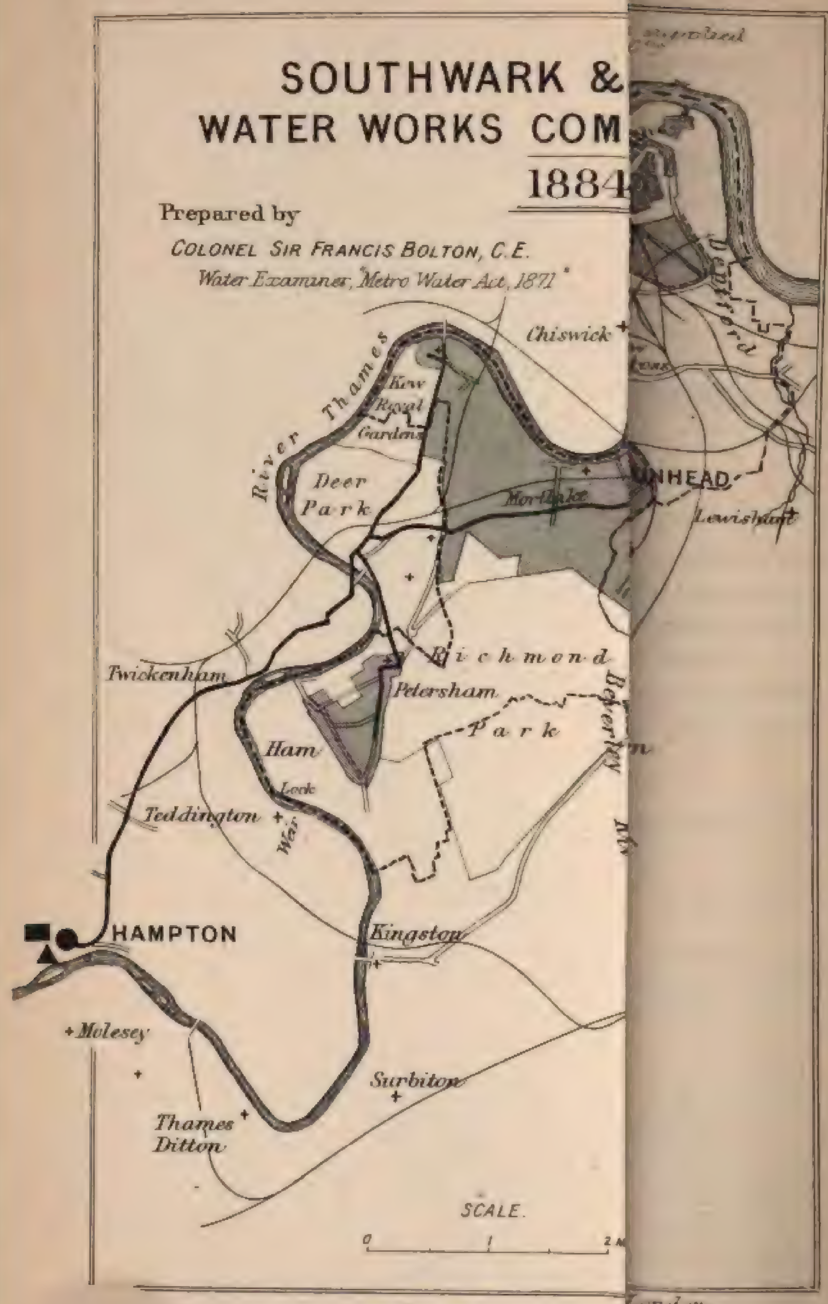
They are together 100 horse-power, the rate of speed being 10 strokes per minute.

They are supplied with steam by four boilers, each 28 feet long, and 5 feet 9 inches diameter, with diameter of tube 3 feet 4 inches.

The coal-store adjoins the boiler-house.

The houses, together with the tower, are of brickwork faced with red and white bricks, and stone dressings.

The lower reservoirs were constructed to contain when full 12,000,000 gallons, the depth of water being computed at 20 feet. They are formed of brickwork and concrete, surrounded by puddle walls, and are arched over on the top.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WATER WORKS COM
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Water Examiner, "Metro Water Act, 1871"
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London

TABLE No. 4A.—Statement shewing the Capital a...

For Year ending	Share and Loan Capital authorised.	SHARE AND L... Ordinary Stocks and Shares.	Preference Stock.	
31st March,	£.	£.	£.	d.
1874	2,000,000	832,160	431,260	0
1875	2,000,000	844,780	494,290	11
1876	2,000,000	863,300	494,700	11
1677	2,000,000	863,300	494,700	5
1878	2,000,000	863,300	494,700	5
1879	2,000,000	863,300	494,700	4
1880	2,000,000	868,800	489,200	7
1881	2,000,000	868,800	489,200	11
1882	2,000,000	897,004	489,200	11
1883	2,000,000	900,800	489,200	8
Total . . .	...	...	...	1

For Year ending	Maintenance of Reservoirs, Filtering Beds, Works, and Pipes for Storing Water.	Maintenance of Mains, &c., Meters and Works connected with Distribution, including Renewals.	Pumping and Engine Charges, including Coals.	en...	...ture ...ent.
31st March,	£. s. d.	£. s. d.	£. s. d.	s.	d.
1874	461 10 4	4,821 8 0	27,387 5 8	6	8
1875	524 8 7	6,193 7 10	22,933 2 1	13	5
1876	581 19 5	5,053 16 3	21,197 10 2	14	11
1877	722 13 5	16,297 6 7	21,331 5 9	1	7
1878	2,112 10 6	16,643 16 0	20,304 19 6	15	4
1879	644 19 5	17,615 3 6	21,607 6 11	14	1
1880	486 9 0	21,268 14 2	21,148 16 3	9	7
1881	1,910 4 0	22,631 4 2	20,264 5 7	18	9
1882	827 18 1	15,489 10 2	19,881 18 10	3	8
1883	769 10 4	12,335 16 2	17,355 4 5	18	3
Total . .	9,042 3 1	138,350 2 10	213,411 15 2	17	3

For Year ending	...et
31st March,	.
1874	52
1875	40
1876	09
1877	33
1878	75
1879	79
1880	63
1881	24
1882	17
1883	58
Total	4

—H. H.

The upper reservoirs were constructed to contain when full 6,000,000 gallons, and are of similar construction, the depth of water being computed at 16 feet.

Repairing shops and stores are situated close to the engine and boiler-houses. Near the entrance are two four-roomed cottages, and a house containing 10 rooms and offices.

The whole of the land occupied by the works contains an area of 14 acres, and is surrounded by an open pale fence 6 feet high.

The Company also own some land on the other slope of the hill.

Telegraphic communication is provided connecting all the stations, and a private telephone line connects the Nunhead works with the Kennington station of the Metropolitan Fire Brigade.

The large mains in the district (excluding the 36-inch main for unfiltered water from Hampton to Battersea Works) are of 30, 27, 24, 21, 18, 16, 15, 12, 10, and 9 inches in diameter, and the services, 5, 4, and 3 inches.

There are about 11,700 fire-plugs. The total area of the district supplied is about 39 square miles, extending from east to west about 13 miles, and from north to south 3 miles.

The total length of the mains and service pipes is about 711 miles, of which about 546 miles are within the Metropolis, and the remainder in the suburbs.

Further statistical details relating to this Company's Works will be found in *Statistics of Supply, Table No.* 4 (*ante*, facing page 504), and concerning its Capital, Income, Expenditure and Profits in *Table No.* 4A, appended.

A map is also appended, showing the parliamentary boundaries of the Company (including the extension acquired in 1884), the position of the principal works, and direction of the mains, the district supplied, and the area under constant supply which are distinguished by different shadings.

V.—THE WEST MIDDLESEX WATERWORKS.

THE West Middlesex Waterworks Company received incorporation in 1806, the 46th year of the reign of George III., by an Act of Parliament empowering them to supply with water from the River Thames the parishes of St. Paul, Hammersmith; St. Mary Abbott's, Kensington; All Saints, Fulham; St. Nicholas, Chiswick; St. Mary, Ealing; St. Mary, Hanwell; Old Brentford, New Brentford, Heston, Hounslow, All Saints, Isleworth; such part of the parish of St. Margaret, Westminster, as lies within the town of Kensington, and a part of the parish of St. Luke, Chelsea, in the county of Middlesex; likewise the parishes of St. Mary, Battersea; St. Mary, Wandsworth; St. Mary, Putney; St. Mary, Barnes; Mortlake; St. Mary Magdalen, Richmond; and St. Anne, Kew, in the county of Surrey.

The share capital was fixed at £30,000, and power was granted to borrow on mortgage the further sum of £50,000.

In 1807, two steam engines of 20 horse-power, with cylinders of 24-inch diameter, and pumps of 18-inch diameter, were erected at Hammersmith, by Messrs. Fenton & Murray, of Leeds, and two reservoirs, to contain $1\frac{1}{3}$ million gallons each, were constructed, upon land about one furlong from the Thames, and a 2-feet diameter brick tunnel was made, from the Thames to the engine wells; the water was pumped up from the wells, into the reservoirs, where it was allowed to subside, and was then distributed to the district by the same engines, through 6-inch and 8-inch pipes made of elm.

In the same year (1807) stone pipes were adopted in lieu of wooden pipes, in consequence of the leakage of water through the wood, and a quantity of 2-inch, 5-inch,

8-inch, and 12-inch diameter stone pipes were laid down in various parts of the district; these pipes, however, were found to be porous, and allowed the water to ooze through under pressure, so that in 1808, both wooden and stone pipes were abandoned, and cast-iron pipes adopted.

In 1809, 3½ acres of land were purchased at Campden Hill, Kensington, and a high-service storage reservoir was constructed, 124 feet above Ordnance datum, capable of containing 3,672,000 gallons. This reservoir was completed, and water pumped in from Hammersmith, on the 4th day of December, 1809, with all due solemnity, a 10-inch main having been laid from Hammersmith to the reservoir, with small mains from the reservoir in the direction of London.

In 1810, an Act was obtained to raise a further sum of money, not exceeding £160,000, and to alter, vary, and enlarge the powers of the Act passed in 1806.

New works were constructed at Hammersmith, adjoining the river Thames, and a 70 horse-power engine was erected by Messrs. Boulton & Watt (subsequently increased to 130 horse-power, by adding an additional pump), with large boilers, and the water was drawn from the Thames by means of 36-inch pipes, laid a considerable distance into the channel of the river. A 21-inch main was laid in 1812, to Kensington Reservoir, from the Hammersmith works, and was continued from the reservoir towards Oxford Street and the Tottenham Court Road.

About this date, a well was constructed in the bank of the Kensington Reservoir, with sluices and 28-inch pipes, and a small engine of 6 horse-power was erected, for the purpose of supplying some of the high-services in the district, which could not be commanded from the reservoir, and a standpipe was also erected at the reservoir; but this small engine was abandoned, as the 70 horse-power engine at Hammersmith was found to be capable of raising the water up the standpipe for the high-service supplies.

In 1813, an Act was obtained to raise a further sum of money, not exceeding £160,000, to enable the Company more effectually to carry on their work.

In 1814, another engine of 70 horse-power (subsequently increased to 100 horses, by enlarging the size of the pump), was erected by Messrs. Boulton & Watt, in the same house, alongside the first 70 horse-power engine; and the two 20 horse-power engines, first erected by the Company, were abandoned and sold in 1819; the two reservoirs were subsequently filled up, and the land sold for building purposes. The first water rental acquired by the Company was in 1811, amounting to the small sum of £335 only, and flattering as were the representations at first of the probable advantages of the undertaking to the proprietors, they did not receive any dividend until March 1819, 13 years from the formation of the Company, and the dividends actually paid from the latter period to 1828 were so trivial, that they did not amount to the common interest of money.

In 1822 land was purchased at Barrow Hill (then called little Primrose Hill), adjoining Primrose Hill, and as the Company's district was extending largely, a reservoir was constructed in 1825, to contain 4¾ million gallons, at an altitude of 190 feet above Ordnance datum, 15-inch and 21-inch mains being laid to supply this reservoir from the Hammersmith pumping station. A well had been sunk at some period at Barrow Hill, opposite a road now called Wells Road, from which, no doubt, the road took its name. In 1826, after the completion of the reservoir, a temporary steam engine, with pumps, was erected over the well, and the reservoir was partially filled by this means, to ascertain its soundness; but as the well produced such a small supply of water, it was subsequently abandoned, domed over, and the surface made good. Water stood in the well at a level of 184 feet from the surface of the ground.

In the construction of Barrow Hill Reservoir a large district was commanded, in case of fire; and the water being supplied from this reservoir to a certain contour level, by gravitation, during the day, enabled the supplies to the services being given in a shorter time, the reservoir being filled at night by the Hammersmith engines.

In 1826, another engine, of 105 horse-power, with boilers, was ordered of Messrs. Boulton & Watt, for the Hammersmith pumping station, which was completed, with an additional engine and boiler house, in 1828. This engine was required in consequence of the Company's operations having spread over a larger area, and to afford an adequate supply of water to the Barrow Hill Reservoir. The engine was subsequently increased in power to 120 horses, by adding another small pump, which was used to raise the water up a standpipe, erected at Barrow Hill Reservoir, in 1839, to supply the high-services in Hampstead parish that could not be commanded by the reservoir.

Another length of 36-inch conduit pipe was carried out a considerable distance into the Thames at Hammersmith, for supplying the well of this engine.

The district of the Company continued rapidly to increase, and in consequence of objections made with respect to the quality of the Thames water, which the Company desired to improve, land was purchased at Barnes equal to about 110 acres (a portion of which was subsequently sold), for the purpose of making large subsiding reservoirs, so that water should be taken in at a certain time of the tide only. In 1838 two reservoirs were constructed at Barnes, of an area of 8 acres each (the acreage and the capacity of both these reservoirs have subsequently been much altered), and the water was taken in at the upper, or western reservoir, upwards of a mile above the Hammersmith pumping station, being allowed to slowly subside, and flow on to the lower, or eastern reservoir, where it passed through very fine wire screens, into a circular shaft, and was thence allowed to flow by gravitation through a 36-inch cast-iron conduit pipe, which had been laid under the bed of the River Thames, into the engine wells. The old conduits, which were laid for taking the supply direct from the Thames in 1810 and 1826, were subsequently removed from the bed of the river.

The supply of water to the district of the Company continuing to increase, a 30-inch pumping main was laid

from the Hammersmith works to the Grand Junction Road, in the Uxbridge Road, in 1851. The number of houses the Company were supplying at this date amounted to about 25,000, and the water pumped to 8¼ million gallons daily. In 1852, in consequence of increased agitation against the Thames water being drawn from the tidal part of the river, an Act was passed, by power of which the point of abstraction of the water from the Thames was removed above the reach of the tide, and Hampton having been selected as the most eligible position for the station, large works were constructed upon land about a quarter of a mile above the village.

Further powers were obtained for increasing the capital of the Company, and the capital was adjusted.

Up to this period £500,478 had been expended upon permanent works, £122,000 of which sum had actually been expended out of income, and no sum of money had been borrowed upon the security of the undertaking. Under this Act the capital of the Company was fixed at £506,300, and the nominal value of the shares was reduced from £100 to £61; powers were also obtained for raising a further sum of money, not exceeding £168,766, and for creating a reserve fund, not exceeding £20,000.

The works at Hampton consisted of two pumping engines of 105 horse-power each, and six boilers, with a 48-inch cast-iron conduit pipe, and screen shaft to the river intake; a 36-inch main was laid from these works, passing under the bed of the river Thames at Richmond, to the subsiding reservoirs at Barnes. These works were successfully completed and in operation in 1855, and the supply from the Thames at Barnes abandoned. It may be more interesting at this point to state, that the two engines have since been enlarged to 120 horse-power each, a new engine of 120 horse-power has been erected, and a second conduit with screen chamber laid from the intake to the engine wells. So rapid has been the progress of the undertaking, that a second 36-inch main has been laid from the Hampton works to the Barnes reservoirs.

Additional land has been purchased, so as to provide for any future extension of works.

In 1853, in consequence of the large quantity of water required to be supplied from the Barrow Hill Reservoir by gravitation, the difficulty of making good the supply by night from the Hammersmith pumping station, the probability of a much larger supply being required for the north-west district, and the fact that the Company had decided to erect a pumping station at Barrow Hill, a 36-inch main was laid, from the Grand Junction Road, near the Bayswater Road (and connected to the 30-inch main from Hammersmith), to the Barrow Hill Reservoir.

In 1854, the Company completed the construction of three filter-beds, of $1\frac{1}{3}$ acres area each, at Barnes, with a total thickness of filtering medium of 5 feet 6 inches, consisting of 2 feet 3 inches of Thames sand, 1 foot of Barnes sand, and 2 feet 3 inches of gravel of various degrees of coarseness; the collecting drains being 6 inches in diameter—pierced earthenware drain pipes, laid 20 feet apart.

In 1855, in consequence of the continual increase in the supply of water to the district, a Cornish engine was erected by Messrs. Harvey & Co., at the Hammersmith pumping station, of 250 horse-power, capable of pumping $4\frac{1}{2}$ million gallons of water per day.

The north-west district of the Company continued to extend very rapidly; so much so, that it became impossible to command many of the houses, "from which applications had been made for a supply of water," from the standpipe at Barrow Hill. The Company, therefore, decided to erect a pumping engine at the Barrow Hill Reservoir for the supply of this upper district; and in 1855, a 30 horse-power engine, with suitable boilers, was erected, and a 15-inch main laid. This engine was enlarged to 45 horse-power in 1865.

In 1852, an Act was passed, to make better provision respecting the supply of water to the Metropolis, and amongst other things it was enacted, "that from and after

the 31st day of August, 1855, every reservoir within a distance of five miles from Saint Paul's Cathedral, in which water for the supply for domestic use of the Metropolis, or any part thereof, is stored or kept by any company, shall be roofed in or otherwise covered over." Accordingly, in June, 1855, the Barrow Hill Reservoir was covered over with brick arches supported upon brick piers.

In 1859, a second engine of 45 horse-power was erected at Barrow Hill, as the district had become so extended, and it was not considered advisable to depend upon one engine alone.

In 1860, an Act of Parliament was obtained to enable the Company to raise a further sum of money, not exceeding £180,000.

In 1862, the Kensington Reservoir was covered in. This reservoir had been out of use since 1855, as it was not considered advisable to cover it in at that time, the supplies to the district being well commanded by the Hammersmith engines. A considerable district is now supplied by gravitation from this reservoir.

In 1862, also, another filter-bed was constructed at Barnes, of 2¼ acres area, the filtering medium being nearly the same as in the three filter-beds before described, Harwich sand being used, instead of Thames sand. Another subsiding reservoir was constructed, to contain 18¾ million gallons, and one of the old reservoirs (the western) was greatly enlarged in capacity.

In 1864, another Cornish engine, of 300 horse-power, was erected by Messrs. Harvey & Co., at the Hammersmith pumping station, capable of pumping about 5 million gallons per day into the district.

In 1866, an additional filter-bed, of 1¾ acres in area, was constructed out of a portion of one of the old reservoirs (the eastern), the filtering medium and mode of construction being nearly the same as for the before-named filter-beds.

Also, in 1866, an Act of Parliament was obtained, for extending the limits within which the Company may

supply water, and for other purposes. The limit comprised the following parishes or places, in addition to the Company's previous district, that is to say, Saint John, Hampstead, Hendon, Willesden, and that part of the parish of Acton which lies to the north of the Great Western Railway, in the county of Middlesex, and all places within the same respectively. By the same Act the quantity of water to be taken from the Thames by the Company was limited to 20 million gallons of water per day.

In 1868, a covered service reservoir was constructed in the Finchley Road, 323 feet above Ordnance level, to contain 2½ millions of gallons. This reservoir was necessary (as the north-west district was rapidly increasing) to command the district in case of fire, and to relieve the Barrow Hill engines in the daytime, so that Hendon and other parts of the district could be supplied by gravitation, the reservoir being filled by the pumping engines in the night-time.

A second 30-inch main was also laid in 1868, from the Hammersmith pumping station to Bayswater, and connected to the 36-inch pumping main in the Grand Junction Road.

In 1869, an Act of Parliament was obtained to enable the Company to raise a further sum of money, by the creation and issue of new shares, not exceeding in the whole £300,000, and the Company, by the same Act, were empowered to borrow on mortgage any sum or sums of money, not exceeding in the whole £200,000; or they may create and issue debenture stock.

In 1871, the Company laid a second 36-inch conduit across the Thames, under the bed of the river, from their works at Barnes, to the Hammersmith pumping station. This second conduit was not absolutely necessary for the supply of water, but to act as duplicate in case of accident to either conduit; but both conduits are open, and water passes through each to the engine wells.

Also, in 1871, an Act was passed to amend the Metro-

politan Water Act of 1852, and to make further provision for the supply of water to the Metropolis and certain places in the neighbourhood thereof, and to make better provision for a constant supply. Regulations were made under this Act, and confirmed by the Board of Trade in August, 1872. From this time constant supply was commenced to be given to all new buildings in the Company's district, and notice having been served upon the Metropolitan authority, three districts in poor localities (one in St. Pancras parish, and two in Marylebone parish) have since been placed under constant supply.

In 1874, another Cornish engine, of 135 horse-power, was erected by Messrs. Harvey & Co., at the Hammersmith pumping station, capable of pumping 2¾ million gallons of water per day into the district.

In 1876, another filter-bed, of 2 acres in area, was constructed at Barnes, the filtering medium and mode of construction being similar to the before-named filter-beds.

In 1877, in consequence of the rapidly increasing north-west district, a new 16-inch main was laid, from the pumping station at Barrow Hill to the Kidderpore Reservoir (Finchley Road), thus giving increased facilities for maintaining the supply to this high-level service reservoir and district.

In 1878, the Company were called upon by the Thames Conservancy to lower a portion of the old conduit crossing the River Thames from Barnes to Hammersmith, to allow the bed of the river being dredged, so as to give a deeper waterway for craft to pass up and down at low tide. This was successfully carried out, but at considerable cost.

In 1880, the Company considered it very desirable to enlarge the capacity of one of the subsiding reservoirs at Barnes, as the supply of water to the district had so rapidly increased. The old reservoir (the western) was thus enlarged from an area of 8 acres to an area of 17 acres, and the capacity increased from 22½ million gallons to 57 million gallons.

In 1882, the supply of water to the Company's district had developed to such an extent, that it became necessary to provide more engine power, and to have reserve in case of accident; two new compound rotative beam engines were therefore erected by Messrs. Simpson & Co. with 7 boilers, at the Hammersmith pumping station, capable of pumping 3½ million gallons each engine, per day, into the district. These engines are of the most economical kind, every improvement having been introduced to make them as perfect as possible.

In the same year (1882), a new reservoir was constructed at Barnes, of 7½ acres in area, capable of containing 24 million gallons of water. One of the old reservoirs (the eastern) was enlarged to contain 17¾ million gallons, and several improvements were introduced to aerate the water as much as possible before it flows upon the filter-beds.

Two new filter-beds were also constructed, a little over an area of one acre each. The mode of construction of these filters differs materially from the old filter-beds. The total thickness of the filtering material is 3 feet 6 inches, consisting of 2 feet 6 inches of Harwich sand, and 1 foot of gravel, sifted to two sizes or degrees of coarseness, which material is laid upon a surface of 2-inch, square, earthenware pipes, butt-ended, and laid side by side all over the surface of the bottom of the filter-bed. The section of these filters is shown in full size in the model.

SUMMARY.

The West Middlesex Company have six Stations, viz.:—

1. *Hampton.*—Intake from Thames, above that of the Southwark and Vauxhall, and Grand Junction Waterworks. The water flows direct from the river, through fine screens, into the engine wells. There are three engines, of 360

horse-power; the other buildings consist of stores, workshops, cottages, &c.

2. *Barnes.*—The water from Hampton is received at this station into four subsiding reservoirs, containing 117,500,000 gallons; and before passing across the river to the pumping station at Hammersmith, is filtered through eight filter-beds, with a joint area of twelve acres. There is a small engine of 6 horse-power for sand-washing purposes.

3. *Hammersmith* is the chief distributing station, and has eight engines, of 1335 horse-power. The other buildings consist of stores, offices, workshops, cottages, &c.

4. *Kensington* has a covered reservoir, containing 3,672,000 gallons, at an altitude of 124 feet above Ordnance datum. There are also cottages and stores.

5. *Barrow Hill* has a covered reservoir, containing 4,750,000 gallons, at an altitude of 190 feet above Ordnance datum. There are also at this station two engines of 90 horse-power, cottages, offices, and stores.

6. *Kidderpore* consists of one covered reservoir, containing 2,500,000 gallons, at an altitude of 323 feet above Ordnance datum. There are also cottages and stores.

TABLE GIVING THE NUMBER OF HOUSES SUPPLIED; THE GALLONS OF WATER PUMPED DAILY; AND THE NUMBER OF GALLONS SUPPLIED PER HOUSE; ALSO THE NUMBER OF GALLONS SUPPLIED PER HEAD, FROM 1853 TO 1883, EACH TEN YEARS.

Date.	Houses supplied.	Gallons of water pumped daily.	Gallons of water supplied per House.	Gallons of water supplied per Head.
1853 . . .	25,880	5,076,000	196	26·1
1863 . . .	33,137	7,128,000	215	28·6
1873 . . .	45,330	9,396,000	207	27·6
1883 . . .	63,370	12,247,000	193	25·7

TABLE SHOWING THE NUMBER OF HOUSES RECEIVING "CONSTANT SUPPLY" FROM 1873 TO MAY, 1884.

Date.	No. of Houses receiving "Constant Supply."
1873	326
1874	401
1875	624
1876	1,314
1877	2,135
1878	2,902
1879	4,080
1880	7,248
1881	9,121
1882	11,197
1883	14,057
To May, 1884	15,702

The total length of mains and pipes in the Company's district is upwards of 402 miles, varying in diameter from 3 inches to 36 inches. As follows:—

Inches.	Yards.
3	121,650
4	277,723
5	69,653
6	60,118
7	39,698
8	2,356
9	33,263
10	7,871
12	8,301
14	1,763
15	8,668
16	11,464
18	1,604
19	1,252
20	1,230
21	12,035
23	1,041
30	12,661
32	43
36	35,746
Total ..	708,140

Equal to 402 miles 620 yards.

Further statistical details relating to this Company's Works will be found in *Statistics of Supply*, *Table No.* 5 (*ante*, facing page 504), and concerning its Capital, Income, Expenditure, and Profits, in *Table No.* 5A, appended.

A map is also appended, showing the parliamentary boundaries of the Company, the position of the principal works, and direction of the mains, the district supplied, and the area under constant supply, which are distinguished by different shadings.

WATERWOR

ture on Maintenance r each year during a period of ten years.

R FRANCIS BOLTON, C.A.

ear).

CAPI Capital Expended.
£.
896,926
910,826
933,184
953,908
962,818
970,938
1,010,380
1,030,353
1,100,937
1,148,123
...

INCOME.

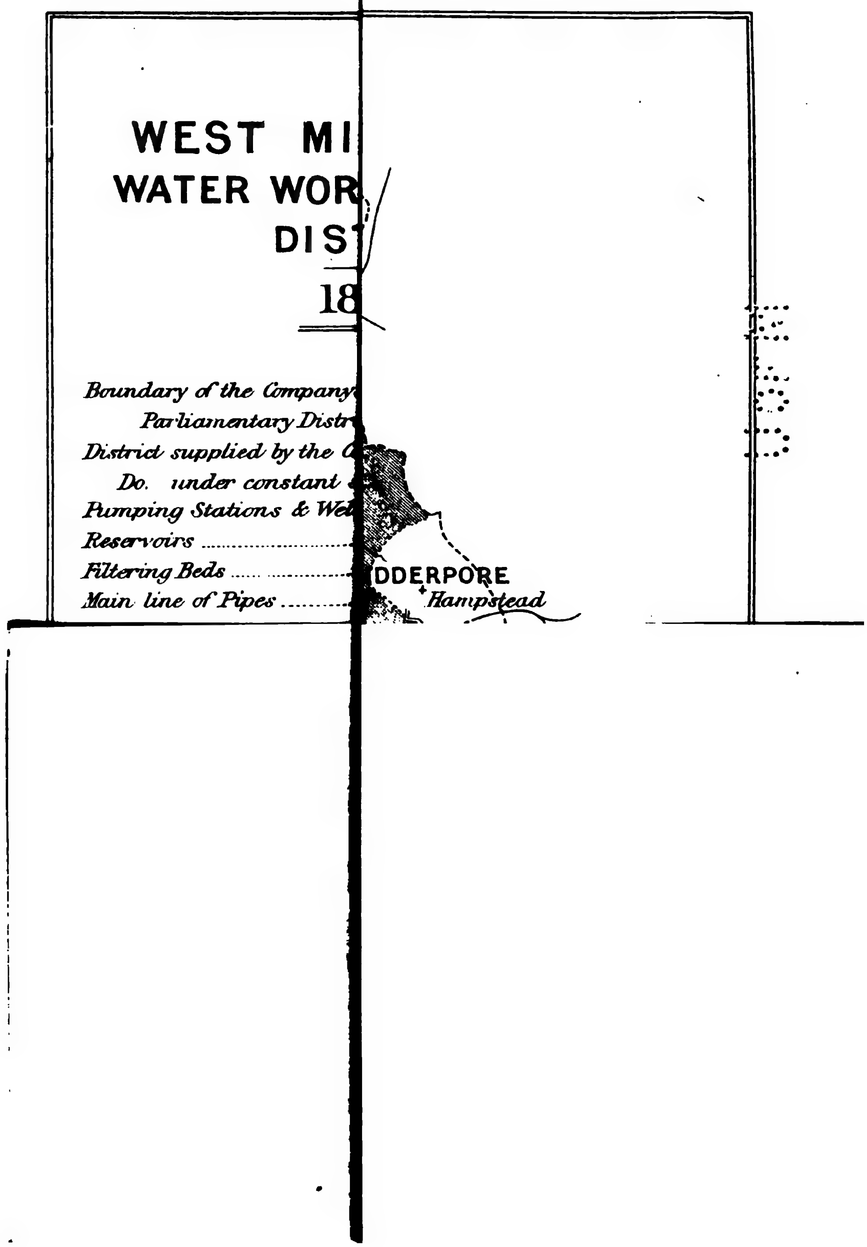
New Water Rents.	Miscellanous Receipts (Rents of Lands, &c.).	Total Income.
£. s. d.	£. s. d.	£. s. d.
130,846 16 10	635 2 6	131,481 19 4
135,179 8 4	679 11 6	135,858 19 10
140,109 9 4	678 10 6	140,787 19 10
147,117 7 8	586 19 0	147,704 6 8
152,538 15 3	626 14 6	153,165 9 9
154,662 12 2	530 13 0	155,193 5 2
159,046 3 5	523 19 4	159,570 2 9
166,023 3 10	416 10 6	166,439 14 4
172,581 16 3	386 13 6	172,968 9 9
179,690 17 2	407 15 9	180,098 12 11
1,537,796 10 3	5,472 10 1	1,543,269 0 4

AGEMENT.

npensations, es, and Mills ; annuation and enses connected Maintenance.	Total E on Mai	General Establishment Charges.	Law and Parliamentary.	Official Auditor and Water Examiner.	Total Expenditure on Management.
	£.	£. s. d.	£. s. d.	£. s. d.	£. s. d.
...	32,90	1,419 13 2	84 11 6	92 17 7	9,844 19 8
...	32,17	1,203 10 9	44 2 0	98 8 9	9,825 3 0
...	31,43	1,267 1 1	56 19 4	101 19 0	10,967 5 9
...	34,29	1,495 14 3	404 3 6	99 13 6	11,867 17 11
...	42,43	1,295 11 1	654 7 3	100 17 4	12,186 17 8
...	44,02	1,342 13 10	1,594 12 2	102 12 0	12,749 5 6
...	39,43	1,809 6 0	513 12 9	102 17 2	12,456 17 5
...	39,52	1,385 5 0	2,632 4 2	101 8 8	14,282 15 2
...	44,07	1,315 2 11	220 9 8	110 14 4	12,108 18 4
...	47,05	1,456 12 1	308 7 0	122 11 4	13,362 9 10
...	387,35	3,990 10 2	6,513 9 4	1,033 19 6	119,652 10 3

Surp		Reserve Fund. Taken from.	Reserve Fund. Carried to.
£. s. d.		£. s. d.	£. s. d.
,769 14 0		...	832 5 11
,145 1 9		...	...
,116 17 5		...	...
,590 7 10		...	...
,994 14 7		...	...
,728 9 1		...	...
...	ividends 24,556 10 0	...	...
...	,, 24,556 10 0	...	...
...	,, 17,423 6 0	...	...
,656 10 6 plus bac		...	...
,001 15 3		...	832 5 11

To face page 602.


WEST MI
WATER WOR
DIS
18
Boundary of the Company
Parliamentary Distr
District supplied by the
Do. under constant
Pumping Stations & We
Reservoirs
Filtering Beds
Main line of Pipes
DDERPORE
Hampstead

VI.—THE GRAND JUNCTION WATERWORKS.

THE Company possessing the above works derived their original Parliamentary powers for supplying water within certain of the western districts from an Act granted to the Grand Junction Canal Company, in 1798, whereby that Company not only had their powers for the construction and use of a canal, with cuts, aqueducts, and reservoirs, confirmed, enlarged and ratified, but likewise had further powers granted to enable them to construct works and lay down pipes (from such canal, cuts, and reservoirs) for the supply of water to the inhabitants of the parish of Paddington and the parts and places adjacent.

By an agreement entered into at a later date, and subsequently confirmed by Parliament in the 51st year of the reign of George III. (1811), these water supply powers were transferred from the Canal Company to a separate body, who, in consequence of such origin and of the fact of their earliest supply of water being derived from the canal and its feeders, adopted the name of the Grand Junction Waterworks Company.

As a natural result of this agreement, the earliest works of this Company were constructed within the parish of Paddington, somewhat south of the canal basin and north of the road formerly known as the Grand Junction Road, a portion of the original site of which works is now occupied by Talbot and Norfolk Squares.

It being sufficiently proved, however, after some extended experience, that the connection between the Canal Company and the Waterworks Company was not mutually advantageous, and that in consequence of the greatly

developed traffic of the canal, it became impracticable for that Company to spare the quantity of water which, by agreement, they had undertaken to afford to the Water Company, a further arrangement was made between the Grand Junction Canal Company, the Regent's Canal Company, and the Grand Junction Waterworks Company, which was sanctioned by Parliament in 1819, whereby the Waterworks Company undertook to transfer their source of supply to the river Thames at Chelsea.

This arrangement, when carried out, was more precisely defined and confirmed by Act of Parliament, in 1826, and from this new source their water was pumped into the reservoirs then existing at Paddington. By the same Act of 1826 enlarged powers, both of district and otherwise, were granted, and the Company were declared to be a Company in perpetuity for supplying water from the river Thames, with a perpetual succession and a common seal.

In 1835, in the reign of William IV., the character of the Thames water in the vicinity of London having somewhat deteriorated, an Act was passed enabling the Company to remove their works and take their supply from a far higher point in the river, namely 350 yards above Kew Bridge.

As this was the first important move in the direction of modern improvement made by the Company, it may be as well to give some slight idea of the work then carried out, and the nature of the improvements effected, under the direction of their very able engineer, Mr. William Anderson, who had been a pupil of the celebrated John Rennie, the first consulting engineer of the Company.

Several acres of land having been purchased near Kew Bridge, on the Middlesex side of the river, a large engine-house, having a handsome, well-proportioned chimney shaft, was erected on that site; and as it was considered of the utmost importance that the Company should be amply provided with the means of increased supply for the then extending district, three steam engines with the requisite number of boilers were erected, having

sufficient power to supply satisfactorily the whole of the Company's London district through more than six miles of cast-iron main of 30 inches diameter—the largest main of any considerable length which had at that time been laid down. This line of main connected the new works with the Company's reservoirs at Paddington, and eventually with the whole of the Company's district. The estimate for these extensive works amounted to £95,000, but in the result that sum was very greatly exceeded. The undertaking was carried out by the well-known contractor, Mr. McIntosh.

The progress of building in the parish of Paddington, which was gradually becoming densely populated, induced the Company, at the urgent request of many of the inhabitants and parties interested in the parish, to obtain Parliamentary powers for removing their works, which were beginning to be an eyesore in the midst of these building improvements. Land was therefore purchased, about the year 1844, on the higher ground at Campden Hill, Kensington, when a commencement was made in the construction of the now extensive reservoirs, with engines and boilers, standpipes and tower, there existing; and the Paddington works, no longer needed, were razed to the ground.

For the further advantage of the water tenants, the Company had been long considering the best method which could be adopted for improving the quality of the water in times of disturbance in the river, and, without any suggestion from outside parties, they voluntarily introduced a system of filtration, which during such times enabled them to deliver perpetually a purified and satisfactory supply of water throughout their district.

In the progress of time, however, in consequence of a totally altered system having been adopted with regard to the house drainage of London, which, at first by permission, but afterwards compulsorily, was placed in connection with the sewers and through them with the river Thames itself, a further deterioration of the water

took place, which affected the tidal portion of the river for some considerable distance above the Metropolis, reaching at times almost to Kew Bridge itself, the highest point of intake at that time of any of the Thames Water Companies. As this was a state of things not likely to improve, and indeed from year to year was found practically more and more intensified, a general Act of Parliament was eventually passed, in 1852, obliging the Companies to go above the tidal portion of the Thames for their sources of supply.

In consequence of such legislation, this Company had their principal intake removed to a part of the Thames about two miles above Hampton Court, where all necessary works had again to be constructed and adapted to the new and altered state of things.

Without going into any detail of the steps by which these and the other existing works of the Company have arrived at their present extent, and constructive perfection, the simplest plan will be to describe in as few words as possible the present condition of those works, and the whole circumstances of their connection with the general supply of this Company's district, both metropolitan and suburban.

The Company's pumping, filtering, and storage stations are five in number.

1. At the intake at Hampton, between the River Thames and the Upper Sunbury Road.
2. At Kew Bridge, on the Middlesex side of the river.
3. At Campden Hill, Kensington.
4. At Shoot-up Hill, Kilburn ; and
5. At Hanger Hill, Ealing.

The present source of supply, when the river is at its purest, is by means of a double intake of water from the River Thames at Hampton, on the borders of Sunbury, whence the supply is allowed to flow into the open reservoirs, passing thence to the filter-beds. After filtration, the water is conveyed into a covered reservoir, from which point the light of day and the external atmosphere with their many injurious influences are not allowed to affect the purity of

its character throughout its whole course, until it reaches the taps and cisterns of the consumers.

In times of disturbance from floods, &c., the river water is received into a third or upper intake which has been constructed somewhat higher up the river, and from which the water flows through gravel screens into a bed of gravel and sand of great thickness underlying nearly the whole of the Company's Hampton station, constituting a natural filter of the most efficient kind, the result of which is at all times to deliver a pure and brilliant water, the lower intakes during the same period being absolutely closed.

Independently of the above process of natural filtration, there are at the Hampton station three filter-beds, with an area of 2¼ acres, through which the water intended for the low-level district, extending from Hampton to Notting Hill, is passed before being pumped into the mains and service pipes; the remaining and more important portion of the supply being pumped on to the Kew Bridge station, there to be again filtered and afterwards distributed throughout the Metropolitan portion of the Company's district.

The other important works at Hampton consist of two subsiding reservoirs, containing six million gallons of water; a large storage reservoir, constructed in 1879, containing forty-five million gallons; and a covered reservoir already alluded to, for the reception of the purified water after filtration, to contain two and a half million gallons; with all necessary pipes, culverts and sluices. There are three Cornish engines, of an aggregate of 784 horse-power, for pumping water, previous to filtration, to the Kew Bridge works, there to be purified and supplied to the Metropolitan district; two rotative engines, of 150 horse-power each, for the supply of the country low-level district above described; and two horizontal engines, with three pumps to each, connected with the underground supply, and capable of raising twelve million gallons per day wholly or in part into the storage reservoir for future use, or into the smaller reservoirs, to be pumped at once to the Kew Bridge works.

Allusion may likewise be made to a small pumping engine for emptying the filters for cleansing operations, and iron boxes for washing the sand. These, with the necessary boiler houses, boilers, coal stores, &c., fairly represent the working arrangements at this station.

In connection with these pumping and filtering works, a line of 30-inch main pipes extends as far as Acton Green, continuing with a pipe of somewhat diminished area through Shepherd's Bush and Notting Hill, terminating in the reservoirs at Campden Hill. This line of pipes forms a supply main to the low-level district comprising Hampton, Hampton Wick, Teddington, Twickenham, Heston, Isleworth, Hounslow, Brentford, Chiswick, Hammersmith, and portions of Acton and Kensington.

A second line of main from the Hampton works, 33 inches in diameter, running almost parallel with the 30-inch main, conveys the water to the Kew Bridge works, where it undergoes subsidence and further filtration, and is eventually forced on for the supply of the London district proper. Various branch mains travel to the several points of the Company's district, and are connected with the service pipes and all the necessary apparatus for the supply of the inhabitants.

The Kew Bridge station, which formerly embraced the principal works of the company, consists of two storage reservoirs, containing 13,500,000 gallons of water; 7 filter-beds, with a joint area of $8\frac{1}{2}$ acres, and 6 pumping engines, with an aggregate of 1031 horse-power, which supply the London district and keep the reservoirs at Campden Hill filled. These engines work into lofty standpipes, which are contained in a handsome tower 180 feet in height. The chimney shaft, in connection with the numerous boilers attached to these engines, has a height of 140 feet. In connection with two of the filter-beds at this station, there is constructed a covered reservoir, of $1\frac{1}{8}$ acres in extent, for the reception of the filtered water which has passed through the filter-beds, and which covered reservoir is in immediate connection with the engine wells, allowing any air that may

have been pumped to escape, and the pressure to be equalised and regulated in the large mains.

The Company's station at Campden Hill, Kensington, consists of three reservoirs, capable of containing 18,000,000 gallons of filtered water, at an elevation of 136 feet above Ordnance datum ; and these works being within the radius prescribed by Act of Parliament, they are all covered over to exclude the action of the external light and heat. There are also three engines, with an aggregate of 532 horse-power, for supplying the higher portions of the district and for filling the reservoir at Kilburn.

In addition to the above storage, filtration, and pumping works, the Company have likewise a station at Shoot-up Hill, Kilburn, where there is a covered reservoir at an elevation of 250 feet above Ordnance datum, capable of containing 6,000,000 gallons of water ; and a further reservoir at Hanger Hill, Ealing, containing 3,000,000 gallons of water, at an altitude of 200 feet above Ordnance datum.

The total length of mains in this Company's district is about 352 miles, 262 being constantly charged. They vary from 30 inches in diameter to 3 inches. The principal trunk mains are connected with those of the West Middlesex and East London Companies ; and the conduit mains at Hampton, for the supply of unfiltered water to Kew, have connections with the similar mains of the West Middlesex Company to Barnes, and of the Southwark and Vauxhall Company to Battersea ; while the large mains from Kew and Hampton are so connected to the 36-inch main from the East London Company's pumping station at Sunbury, that the power at those works could be applied at very short notice to the supply of the Grand Junction Company's district, and the works of the latter company could be made to serve any portion of the East London Company's district as far east as Loughton in Essex.

The Company supply more than 48,000 houses, of which 30,000 are supplied on the constant system, great progress

having been made in this direction during the past three years. Previously only about 2000 houses were so supplied; but at the present time the only portion of the Company's district supplied on the intermittent system is that lying between Notting Hill and St. James's, Westminster.

The following Acts of Parliament have been passed from time to time to meet the growing requirements of the Company:—

In 1855, powers were granted to raise an additional sum of £200,000 by shares, and £150,000 by bonds, including £23,000 of their former capital, repealing the power given to raise £46,000 formerly granted.

In 1856, an Act was passed introducing some modifications in the Company's charges.

By an Act passed in 1861, the limits of supply were extended to include Chiswick, Acton, Isleworth, Twickenham, Teddington, Hampton, Hampton Wick, Hampton Court, Bushey Park, Whitton and Hanworth.

In 1868, an Act was passed by which the capital of the Company was authorised to be increased to

Share capital . . .	£1,000,000
Loan capital . . .	250,000
Total . . .	£1,250,000

And an Act was passed in 1878, empowering the Company to raise a further amount of capital, equal to £300,000, with borrowing powers to the extent of £75,000.

The Company's works, as they now exist, comprise the following five stations:—

1. Pumping and filtering station at Hampton.
2. " " " Kew Bridge.
3. Storage reservoirs and pumping station at Campden Hill, Kensington.
4. Storage reservoir at Kilburn.
5. " " Ealing.

having been made in this direction during the past three years. Previously only about 2000 houses were so supplied; but at the present time the only portion of th

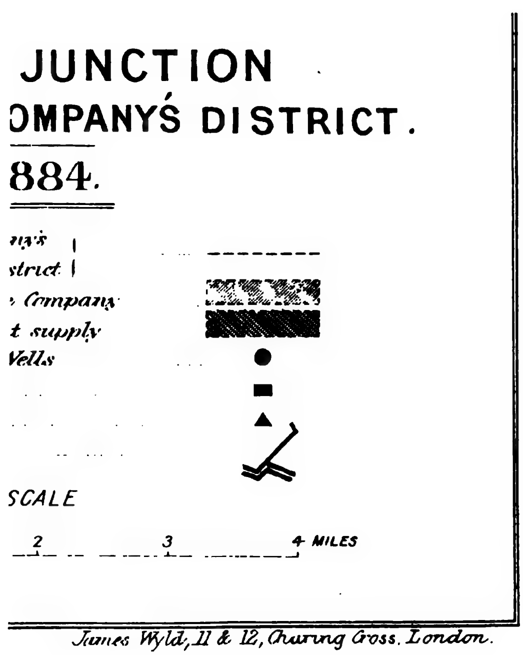


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TABLE No. 6A.—Statement shewing the Capit Maintenance

Prepared (ANCIS BOLTON,

For Year ending	Share and Loan Capital Authorised.	SHARE AN: Ordinary Stocks and Shares.	Preference Sto	CAP: tal Expended.
31st March,	£.	£.	£.	£.
1874	1,250,000	911,175	...	,091,623
1875	1,250,000	939,405	...	,165,099
1876	1,250,000	965,415	...	,165,006
1877	1,250,000	966,860	...	,170,125
1878	1,250,000	976,785	...	,175,491
1879	1,250,000	993,775	...	,201,531
1880	1,625,000	1,022,320	...	,276,164
1881	1,625,000	1,050,000	...	,312,109
1882	1,625,000	1,050,000	...	,321,108
1883	1,625,000	1,060,000	...	,356,722
Total . . .	...	...	...	...

For Year ending	Maintenance of Reservoirs, Filtering Beds, Works, and Pipes for Storing Water.	Maintenance of Mains, &c., Meters and Works connected with Distribution, including Renewals.	Pumping Engine Ch including	tions, Mills; ons and connected nance.	Total on M
31st March,	£. s. d.	£. s. d.	£. s		£.
1874	369 8 9	4,960 17 2	19,159		36,7
1875	277 0 5	6,032 14 3	14,769 1		32,7
1876	334 1 10	5,644 18 6	22,963		40,8
1877	825 5 10	4,393 12 7	37,173 1		56,0
1878	253 13 7	4,648 3 5	27,930		46,7
1879	197 11 11	7,662 4 0	17,807 1		40,6
1880	3,034 16 1	9,480 4 10	13,034 1		41,6
1881	191 7 11	8,943 15 2	13,595		39,0
1882	356 17 10	10,885 1 8	14,092 1		44,6
1883	661 6 1	6,868 15 0	13,988		44,1
Total . . .	6,501 10 3	69,520 6 7	194,514 1		423,3

For Year ending	Total Expenditure on Maintenance and Management.		Di
31st March,	£. s. d.		
1874	45,375 5 4		55
1875	40,691 7 11		59
1876	48,711 8 3		63
1877	65,163 7 9		47
1878	55,778 19 6		47
1879	51,412 8 6		66
1880	52,502 16 10		72
1881	50,542 7 6		76
1882	57,343 16 0		86
1883	57,310 5 3		84
Total	24,832 2 10		66

Further statistical details relating to this Company's Works will be found in *Statistics of Supply*, *Table No.* 6 (*ante*, facing page 504), and concerning its Capital, Income, Expenditure, and Profits, in *Table No.* 6A, appended.

A map is also appended, shewing the parliamentary boundaries of the Company, the position of the principal works and direction of the mains, the district supplied, and the area under constant supply, which are distinguished by different shadings.

VII.—THE LAMBETH WATERWORKS.

THESE works were originally established under an Act of Parliament passed in the year 1785—"For supplying the inhabitants of Lambeth and parts adjacent with water from the river Thames, between Westminster Bridge and the confines of the parish of Christchurch."

The works thus sanctioned were erected in Belvedere Road, on a small piece of ground bordering on the river, close to the southern end of the footway over the present Charing Cross railway bridge, and consisted of a pumping engine of 20 horse-power, with wooden pipes laid therefrom into the district, by which the water was pumped directly from the river into the cisterns of the consumers.

The portion of the water district above widely defined under the Act, situated adjacent to the works, was at that time expanding and forming into a densely populated locality.

A large area of St. Mary, Lambeth, and the contiguous parishes, lay at comparatively low levels, comprising many fields and a good deal of garden ground, which in the rainy seasons were often covered with water, and in the winter frequently afforded the diversion of skating to thousands. The names of many of the places to this day indicate that they were situated on marsh lands with raised roads, or causeways, running through them ; thus, Lambeth Marsh was bounded by the parish of Christchurch and the Westminster and Blackfriars Roads. The area known by the name of St. George's Fields was bounded on the south by Newington Causeway, on the west by St. George's Road, on the north and west by the parishes of Lambeth and Christchurch, and on the north-east by Great Suffolk

Street, formerly called "Dirty Lane." Not far removed from the southern foot of Blackfriars Bridge, the Upper Ground, Broadwall, and Narrowwall, were roads raised above the flood waters of that locality, and the ordinary spring tides of the Thames. Near the foot of Waterloo Bridge was the site of Cupars Bridge—which crossed a low place and water-course, known afterwards as the Arnold outlet, subsequently converted into a covered sewer, which drained a large tract of swampy land, comprising what is now York Road, and the lands, east, west, and south, for a considerable distance. Excepting some parts of the public roads, the natural surface of the greater portion of these districts was, and still is, under the ordinary high water-mark of the Thames; in some places, as much as five feet.

The population, except in the part above referred to, was at first thin, the principal portion of it being scattered on and contiguous to a line of street running from the foot of Blackfriars Bridge, in a direction nearly parallel to the Thames, to the foot of Westminster Bridge. From the widening and improvement of this great thoroughfare, now known as the Commercial and Belvedere Roads, the wharf property has become extremely valuable, and only a small relic of this ancient street or road now remains, viz.—the south end of Pedlar's Acre. Further to the south, Stangate, Church Street, Fore Street, and Princes Street had been built, the immediate neighbourhood of Lambeth Palace having been improved by embankments, and inhabited many years previously. Large tracts of land in Lambeth, subject to inundations from the river, had been in a state of saturation for centuries; and as buildings advanced, the stagnant pools and ditches became receptacles for filth and sewage water, which so affected and percolated through the soil, that the wells sunk into the land springs became unfit for domestic uses, and many which previously furnished good water, were obliged to be abandoned.

Prior to the year 1810, the southern Metropolitan suburbs derived little benefit from artificial drainage or underground sewers, the Commissioners of Sewers for Surrey,

&c., not having been invested with powers to make such works until they obtained an Act for that purpose in 1809. Their operations afterwards had a most beneficial influence, and rendered many swampy places fit for building sites, among which may be noticed the large area of Prince's Meadow and St. George's Fields, which prepared the way for the erection of Bethlehem Hospital and many large buildings, such as otherwise could never have been erected in that locality.

It is also worthy of notice that the construction of Waterloo Bridge, and the formation of the road from it to the Obelisk, acted as a stimulus to builders to improve and extend their operations.

From the early history of the Lambeth Waterworks Company's progress, it appears the proprietors contended with difficulties for a long time; and at various periods (in the whole amounting to nearly twenty years) no dividends were paid by the Company, necessity having compelled them to expend the whole receipts on the works and to carry on the undertaking with the most rigid and even parsimonious economy.

Down to the year 1810 the improvement of the works had been progressive, but the extension of the supply was slow. At this period, however, an impetus was given to building operations in Lambeth and parts adjacent, by the drainage operations above referred to, which were carried out on a large scale, leading to a rapid increase in population. This called for the construction of water works of an enlarged and improved character, and the Company were not slow to meet the demands of the rising community.

Between 1810 and 1825 the works were considerably extended, that is, additional engine power was erected at the Belvedere Road station, and the pumping mains and service pipes were extended, cast-iron instead of wood pipes having been introduced about the year 1820. Improved means were also adopted for straining the water through screens before entering the engine wells, although at this period no attempt had been made at filtration.

About 1832 an open reservoir was constructed on Streatham Hill, and a 20-inch cast-iron main was laid from the Belvedere Road works to supply it, with the view of ensuring a constantly-available service of water in case of fire (water being only obtainable previously when the pumping engines were at work), and also to supply houses in Brixton and its vicinity at a higher level than that to which the water had previously been conveyed.

In 1834 the Company obtained a second Act of Parliament for increasing their powers, and under such Act two large open reservoirs, of 12,000,000 gallons capacity, were, about 1835, erected at Brixton on the extensive area of land on which the present town pumping station has since grown up.

The reservoirs were made in duplicate to contain a depth of about twenty feet of water, the upper fourteen feet only being drawn off for use, while the lower portion served for collecting the grosser impurities subsiding out of the water, the sullage being run to waste occasionally into the drains. In addition to this means of improving the condition of the water before service, each reservoir had a separate compartment walled off at the end, which was filled with a stratum of gravel four feet thick, through which the water was strained before use.

At this period a small pumping engine was erected at Brixton, to pump the improved water to Streatham reservoir, and one also at Streatham to provide additional supplies for the more elevated portions of the district beyond the reach of the service from the Streatham reservoirs. The works were generally much extended and improved, to meet the constantly-increasing demand for water, and also to enable the Company to afford high service supplies, including water-closets, which were at this period beginning to come into use.

The great increase in the population of the Metropolis obliged all the Water Companies to keep extending their areas of supply, and in several places, particularly in the Lambeth district, over which the Southwark and Vauxhall

had and have joint powers, competition for the fresh supplies was set up so as to produce loss to the Companies and inconvenience to the consumers. Consequently, in or about 1841, all the Companies agreed to define their boundaries, and the competition between the Lambeth and Southwark Companies has since practically ceased by mutual agreement.

About 1845 The Health of Towns Commission was appointed, and the better drainage of London became a prominent question. The cesspool system, hitherto almost universal, began to be abolished as drainage by sewers was extended, and the foul matter hitherto stored under the ground surface of the Metropolis began to be gradually transferred to the Thames.

Hence in a year or two the river, from being a comparatively pellucid stream, became itself a polluted sewer on an enormous scale; the mass of tidal water, black and foul, passing continually up and down, thus creating a condition of things which culminated in the cholera outbreaks of 1845 and 1849.

It soon became evident that the Water Companies could not continue to draw water from the tidal way, and in 1847 the Lambeth Company took the initiative, by preparing an extensive scheme for removing their intake works to Thames Ditton, a mile or two above Kingston Bridge, obtaining in the following year (1848) an Act to sanction such works, and to enlarge the Company's district and confer other general powers.

By this Act the district was extended to include the parishes of Thames Ditton, Long Ditton, Kingston-on-Thames, Malden, Putney, Wimbledon, Morden, Merton, Mitcham, Tooting, Clapham, Wandsworth, Battersea, Streatham, Croydon, Newington Butts, St. Mary Newington, Camberwell, Bermondsey, St. Mary Lambeth, Rotherhithe, Horselydown, St. Saviour, St. George the Martyr, Christ Church, St. Olave, St. Thomas and the Clink Liberty. By the subsequent Act of 1872, the outlying portions of Esher, and East and West Molesey were added,

whereupon the supply was extended to them. Thus the district is of very large dimensions, stretching over 17 miles from east to west, and 11½ miles from north to south, embracing an area of about 100 square miles.

The works sanctioned under the Act of 1848 consisted of a new intake, with a series of sand filters, from and adjoining to the river at Thames Ditton, together with the erection of four pumping engines of 600 horse power in all, with boilers, buildings, coal stores, and machinery for landing and depositing the coals. Also offices, workshops, and all the minor works and details connected with such an establishment.

A cast-iron main pipe of 30 inches diameter, and over 10 miles in length, was also laid down from the engine wells to the reservoirs at Brixton. Of this length, 6 miles were laid in public roads, and 4 miles through land, a sufficient width of the latter having been purchased to accommodate four such mains for future use.

These works were completed by the end of 1850, and were capable of delivering 10 million gallons of water per day into the Brixton reservoirs, this new supply being introduced early in January, 1851.

The quantity of water distributed by the Lambeth Company in 1831, averaged about 800,000 gallons per day; the service being intermittent, and the water turned on to different portions of the district supplied for about an hour per day for three days in the week.

In 1836, the quantity had increased to 2 million gallons per day, and at the date of the opening of the new works, in 1851, had got up to three million gallons.

When, however, the new water, of greatly improved quality was introduced, the consumption rapidly went up to 4½ million gallons per day in 1852, and has continued to increase at the rate of about half a million gallons per day per year to the present time; the average supply now amounting to about 16 million gallons per day.

Since the opening of the new works in 1851, to the present time, the increase of population, especially in the

country district, has been so rapid that scarcely a year has passed without the necessity arising for making large and costly new works to keep pace with the ever-increasing demand for water.

The opening of the Crystal Palace, in 1854, gave a great stimulus to building operations, and a considerable resident population sprang up in Dulwich, Upper Norwood, Sydenham Hill, Forest Hill, and the adjoining high level localities. Works for the supply of these places were constructed by the Lambeth Company, and were brought into use in 1856.

A pair of 30-horse power engines, with boilers, pumps, buildings and coal stores, were erected at the Brixton station, and a 12-inch cast-iron main, 3½ miles in length, was laid to the high ground at Rock Hill, near to the Palace, where a covered service reservoir of 615,000 gallons capacity was constructed.

The water level of this reservoir is 363 feet above Ordnance datum, the engine-lift from Brixton being (with friction) 330 feet, and large service mains were laid to distribute the water.

Moreover, in order to give high supplies at the most elevated spots, a stand pipe was erected in a building of obelisk form, over which the water was forced some hours each day to a height of 415 feet above Ordnance datum, giving a corresponding pressure in the service pipes.

In the year 1852, the Metropolis Water Act was passed, making it illegal, after a certain time allowed for constructing new works, for any Company to supply water below Teddington Weir; for although the Lambeth Company had previously, as before described, voluntarily moved their intake far above this point, still several of the Companies continued at that period to use the river water within the tidal influence. Under this enactment the Chelsea, West Middlesex, Grand Junction, and Southwark Companies, all in a few years moved up the river, the first to Thames Ditton, adjoining the Lambeth works, and the latter three to Hampton. It was also under this Act ordered that all

filtered water reservoirs within a radius of 5 miles from St. Paul's Cathedral should be covered over, and the Brixton and Streatham reservoirs of the Lambeth Company were accordingly, in 1855, covered with brick arches, supported on cross walls.

No greater improvement was ever effected in Water-works construction than thus covering the reservoirs, and protecting the water from all atmospheric impurities, as well as from light and heat. In proof of the efficiency of this procedure, it may be mentioned that reservoirs, which when open required cleansing out twice a year, owing to the vegetable growth, aerial impurities, and animal life constantly accumulating therein, were found to be perfectly free from any objectionable deposit for five years after being covered over.

The Rock Hill works above described had not long been in operation before the lower levels south and east of the Crystal Palace, comprising Lower Norwood, Selhurst, Penge, and Lower Sydenham, were being rapidly built over, and to make provision for the supply of these parts with water, the Company carried out an extensive series of works between the years 1859 and 1861.

Brixton was again the base of operations, and two 60 horse-power engines, with all the necessary adjuncts, were erected there, and a pumping main, varying from 18 to 12 inches in diameter, and five miles in length, was laid to Selhurst, in South Norwood, where another covered service reservoir, of two-and-a-half-million gallons capacity, was constructed. The water was pumped through the 18-inch portion of the main to Streatham Reservoir, where an increased supply was furnished, while the residue continued on through the 12-inch main to Selhurst, and from thence a series of large service mains, with smaller distribution pipes, carried the water to the localities to be served.

The Selhurst Reservoir high water level is about 220 feet above Ordnance datum, while a loop pipe is laid underground up to a level of 260 feet, to act as a stand pipe to serve intermediate higher levels.

About this period, viz., in 1863, the town of Kingston-on-Thames required an improved water supply. To effect this, a reservoir was constructed in Coombe Warren, Kingston Hill, of 1,150,000 gallons capacity, and a 12-inch main, three miles long, was laid to fill it from the principal pumping station at Thames Ditton.

This arrangement has since been enlarged into a really separate water works, served by a special engine and entirely independent of the general works, and has been extended to supply not only the town of Kingston, but the populous neighbourhoods of Surbiton, Molesey, Esher and adjacent parts.

All these extensions of the water supplies were beginning to reach the safe limit of pumping power at Ditton, with reference to having sufficient spare power in reserve in case of accident; and therefore, in 1864, two additional pumping engines, of 300 horse-power, with pumping wells, houses, and all other conveniences (of sufficient size to serve for duplicating the power in future), were erected at Ditton, together with further boilers and the necessary adjuncts, making a total at that period of 900 horse-power at this station.

In 1866 the extent of the water requirements had begun to exceed the power of production; it being difficult, especially when the Thames was in flood, to filter the required quantity through the very limited sand area of the first filters; and an extensive scheme, embracing a series of three subsidence reservoirs with an enlargement of the original filter-beds, was designed and carried out on the land fronting the river at Thames Ditton.

By means of these works the river water was first admitted from the river to the reservoirs, each of which was provided with a vertical gravel screen or rough filter at the draw-off end, similar to that before described at Brixton Reservoirs; and after an interval of rest for subsidence, the water slowly passed through these screens out to the filters and thence to the engine wells.

Simultaneously with the enlargement of the Ditton

Works, arose the necessity for conveying the water to the town district, and the need for another main pipe to Brixton became evident. This meant an expenditure of £60,000. Yet the outlay was met, and a second 30-inch cast-iron main was laid, to convey the second ten million gallons per day to Brixton, all the land, not only for this but also for two other such mains, having been originally purchased. This work was completed in 1869, when it was thought that the works had become sufficient for a lengthened period; but it was soon evident that the requirements of the suburban district on the higher level served from Brixton were becoming of pressing necessity, and must be attended to.

The Lambeth Company at the latest date above cited were paying $5\frac{1}{2}$ per cent to their shareholders. During 20 years of their earlier career they paid nothing.

To continue the recital of the extension of works. In 1870 it became necessary to re-arrange and enlarge the Brixton works, and three new engines, of 200 horse-power were added, to pump water to Rock Hill and the country district, with the necessary extension of mains and service pipes for that purpose.

The filters at Ditton also required enlargement, and the subsiding reservoirs, previously noticed, were converted into filters, as being more serviceable in that shape.

In 1871 new large mains were laid from Brixton to Selhurst, and in the same year, under the powers of a new Act obtained in 1871, the pipes were extended and a service of water afforded to the new outlying districts of Molesey and Esher, embraced in that Act.

The Act of 1871 was, however, specially applied for and obtained, for the purpose of removing the Company's in-take from Ditton to Molesey.

Notwithstanding the works hitherto described for improving the quality of the water, it was found that during river floods it could not be filtered clear and bright, chiefly owing to the stream of the Mole river, which joins the Thames below Hampton Court Bridge.

The Company therefore sought and obtained powers under that Act to remove their intake to West Molesey, more than four miles higher up the river, and proceeded at once to carry out the works.

The necessary land being purchased (about forty acres), the construction of the new intake from the Thames three miles above Hampton Court Bridge was completed, and an underground conduit, over four miles in length, from the intake passing through West and East Molesey and Thames Ditton to the existing works at Ditton, was constructed, capable of conveying thereto twenty million gallons of water per day by gravitation.

The new intake is furnished with double wire gauze screens, to prevent fish as well as leaves and other floating impurities entering the conduit; and a sluice house, with large screw sluices, is constructed on the adjoining land belonging to the Company, to control the flow of water.

The conduit consists of an oval-shaped structure, 5 feet 9 inches high and 4 feet 9 inches wide, with intervals of cast iron pipes 54 inches in diameter, the latter being laid through the towns of West and East Molesey and Thames Ditton, and the former through lands and country roads.

These works were completed in 1872, and a considerable improvement was effected thereby in the quality of the water, that of the river Mole being now quite avoided; but it was still evident that, during severe river floods, the water could not be effectually filtered, and steps were taken to construct the large store reservoirs adjoining the new intake, the works of which were completed early in 1875.

These reservoirs, two in number, are capable of holding 125 million gallons of water; and the works embrace a pair of pumping engines of 100 horse-power, with engine and boiler houses, coal stores, cottages, and other minor works. The engines lift the river water into the reservoirs.

During the construction of the reservoirs, a very large volume of subsoil water, contained in the deep gravel bed overlying the London clay at that part, had to be en-

countered. This water being rain naturally filtered, and of great purity, was utilised by means of a double series of glazed stone-ware pipes, 12 to 24 inches diameter, perforated with small holes and laid along the river sides of the reservoirs, extending inland at the ends and between them, to conduct the water to the engine wells. This supply, to the extent of seven or eight million gallons per day, is used to replenish the store in the reservoirs during floods, when the river intake is entirely closed.

By these means the Company possess the power of tiding over a flood of eighteen to twenty days' duration, and by judicious pumping it is found that within such period the reservoirs when drawn down for service to Ditton can always be replenished with clear water, which has the advantage of being impounded for lengthened periods and exposed to the atmosphere in rest, to allow of the subsidence of matter held in suspension.

These extensions of the works from Ditton to Molesey, embracing the new intake, and including 35 acres of land, cost the Company near upon £180,000, which sum was expended wholly with the object of improving the quality of the water.

In 1881 a further extension of the filters and works at Ditton was effected.

The extension comprised a service reservoir of 3,000,000 gallons, with a series of 4 filters of 1 acre each, and a pair of engines of 140 horse-power, to pump from the lower level of the earlier filters adjoining the river to the service reservoir; conduits, engines, and boiler houses, boundary walls and other necessary works, also being constructed in connection therewith.

These new filters bring the total sand-filtering area up to nearly eight acres in extent; but it may be stated that the Company possess sufficient spare land for the construction of four acres additional filtering area when required.

Since the completion of the Molesey extension, and in addition to the above-named reservoirs and engines, the

Company have carried out the following works and extensions, viz.:—

In 1875 the erection of a pair of engines at Ditton of 300 horse-power.

Also in 1876 and 1877 the erection of a pair of combined engines of 130 and 160 horse-power respectively, with boilers, and buildings, to pump water to a new covered reservoir constructed at Crown Hill, Norwood, at a level of 315 feet above Ordnance datum, to hold 5,000,000 gallons of filtered water; together with about five miles of pumping and service mains, varying from twelve to eighteen inches in diameter.

The object of these extensions was to meet the increasing demands of the country district, and to improve the services in those parts lying at levels intermediate between Streatham and Rock Hill reservoirs, the parts so served being the upper portions of Dulwich, Norwood, Beckenham, Sydenham, Forest Hill, Ravensbourne Park, &c.

In 1875, a main 24 inches in diameter, and over three miles in length, was laid down from Brixton to near the Obelisk in Southwark, to supply more water at higher pressure generally, as well as with the view of commencing to carry out the system of constant supply. Between this date and 1880 large mains were laid in various parts of the district, viz.: one of 12 inches in diameter and 4 miles in length, from Norwood reservoir to Wimbledon, and one of the same size and 4½ miles in length, from the same reservoir to Beckenham, to increase the supply in that part of the district.

Since 1881, besides various pipe extensions, two engines have been erected at Brixton of, respectively, 120 and 130 horse-power; the first as a duplicate for safety to the engines supplying Rock Hill, and the second as a spare engine to pump to Selhurst and Norwood reservoirs, as well as a single engine, 180 horse-power, with boilers and building, just completed at Ditton. These works bring the extensions down to the present time, to which, however, *must be* added the laying of a third 30-inch main, over ten

miles in length, from Ditton to Brixton, commenced in November last, and to be completed in 1885.

The stations (8 in number) and works thus described may be usefully summarised as follows :—

No. 1 station at Molesey. The new intake; the store reservoirs for river and spring water of 125,000,000 gallons capacity; the pumping engines of 100 horse-power, and the conduit 4 miles long from the river to the Ditton works, capable of conveying thereto 20,000,000 gallons of water in 24 hours.

No. 2. The principal pumping station and old intake at Ditton; filters of nearly 8 acres in extent; 2 service reservoirs of 3,000,000 gallons capacity; 12 pumping engines of 1550 horse-power; offices, coal stores, and machinery for landing coals; workshops, general stores, workmen's cottages and other buildings, and general pipe yard. Two cast-iron mains of 30-inch diameter and each 10¼ miles long, to deliver water into the Brixton reservoirs, and the third such main now being laid.

No. 3 station, Coombe, Kingston Hill. Covered reservoir for filtered water, of 1,150,000 gallons capacity. Pumping mains and turncock's cottage.

No. 4. Second lift pumping station at Brixton. Two covered reservoirs, holding 12,000,000 gallons of filtered water; 12 pumping engines of 930 horse-power; the Company's principal offices; coal and general stores, stabling, workmen's residences, and pipe yards.

No. 5. Streatham station. Two covered reservoirs for filtered water, of 7,500,000 gallons capacity.

No. 6. Norwood station. Covered filtered water reservoir of 5,000,000 gallons capacity. Turncock's residence, etc.

No. 7. Rock Hill station. Covered filtered water reservoir of 615,000 gallons capacity, cast-iron tank of 100,000 gallons capacity elevated on a structure of brickwork and roofed over; stand pipe to give additional pressure up to 415 feet above Ordnance datum for high service. Turncock's cottage, etc.

No. 8. Selhurst station. Filtered water covered reservoir of 2½ million gallons capacity, with spare land for a duplicate. Turncock's cottage, etc.

SUMMARY OF FILTERED WATER RESERVOIRS.

2 at Brixton . . .	12,000,000	gallons capacity,	115 ft.	above Ordnance datum.
1 „ Combe . . .	1,150,000	„	180 ft.	„ „
2 „ Streatham . .	7,500,000	„	200 ft.	„ „
1 „ Norwood . .	5,000,000	„	315 ft.	„ „
1 „ Selhurst. . .	2,500,000	„	220 ft.	„ „
2 „ Rock Hill . .	615,000	„	365 & 390 ft.	„ „
Total 9 containing	28,765,000	gallons.		

The entire district of the Company contains about 95 miles of main pipes, varying from 9 up to 30 inches in diameter, and about 540 miles of service pipes, from 3 up to 7 inches in diameter.

CAPITAL EXPENDITURE.

To the passing of the Act of 1848 . .	£143,800.
To the present time about	£1,550,000
Gross Revenue about	£190,000.

CONSTANT SUPPLY.

The Company are at present giving constant service to 29,536 houses, or 39 per cent. of the entire district; and in 28,564 of these the fittings prescribed by the Board of Trade regulations have been provided.

The Company have always given a constant supply (where the mains were constantly charged) upon the application of consumers who had provided the prescribed fittings, and otherwise complied with the Company's requirements. The number of such supplies in 1877 amounted to about 3000. The sanitary and other benefits that would accrue to the public by converting the intermittent into a constant supply, had not, however, been lost sight of by the directors

of the Company, and the Board, on the advice of their engineer, having laid out very large works for the purpose, determined in 1878 to commence the adoption of the system generally throughout their district, proceeding gradually section by section. The results down to the present time are given in the following table, which relates only to the Company's town district:—

Division or District.		Date, when placed on Constant Supply.	Number of Waste Meter Districts.	Number of Supplies.	Population Supplied.
Town.	No. 1 . . .	Oct. 1, 1878	6	2,216	16,112
	No. 2 . . .	Jan. 1, 1880	20	7,404	61,538
	No. 3 . . .	July 1, 1881	12	4,337	34,016
	No. 4 . . .	Oct. 1, 1882	6	1,835	14,752
	No. 5 . . .	May 1, 1883	9	3,900	29,912
	No. 6 . . .	Nov. 1, 1883	6	2,919	23,350
	No. 7 . . .	April 2, 1884	1	290	2,320
Country A. . .		July 1, 1882	3	1,534	12,224
Coventry Park .		June 1, 1882	1	180	1 440
Totals . .		..	64	24,615	195,664

The above divisions include the whole of the Company's town district, extending northward to the river Thames from a line drawn from Vauxhall Bridge by Kennington Church and Camberwell New Road to Camberwell Green, comprising the poorest and most densely populated part of their district.

Notices have been served, in accordance with the Metropolis Water Act 1871, on the Metropolitan Board of Works, for three more divisions of constant supply, the particulars of which are given below.

Division or District.	Number of Supplies.	Proposed Date of Constant Supply.
No. 8.	1,534	Oct. 1, 1884.
No 9.	3,517	Jan. 1, 1885.
Country B.	3,757	April 1, 1885.
Total . . .	8,808	..

By the beginning of April 1885, 38,344, or nearly half the houses in the Company's entire district, will be receiving the benefits of a constant supply of water at high pressure.

The satisfactory results that have been thus obtained for the public have entailed considerable expense on the Company, and also in many cases great difficulty in forcing the owners of small property to provide the prescribed fittings.

Shortly after the first district was placed on constant supply, it was found that the waste of water through defective fittings and house service pipes was so great, in some parts amounting to 30 and 40 gallons per head per day, that the system could not be extended except at a ruinous cost to the Company. It was also found that the ordinary house to house inspection of fittings was quite inadequate to check the waste, the greater part of which was hidden or underground. It therefore became a matter of vital importance to adopt some means to prevent this great loss, so that the system of constant service could be extended at a moderate cost to the Company.

The attention of the directors was drawn to the system of waste-detecting meters patented by Mr. Deacon, the engineer of the Liverpool Corporation, and it having been found that the system worked effectually in Liverpool, it was introduced into the Lambeth Company's district in 1879.

The adoption of this system has proved of such effect in the prevention and suppression of waste, that the Company have been enabled to extend the area of constant supply by regular sections; and at the present time, 64 meters, supplying 24,615 houses, with a population of nearly 200,000 persons, are fixed and in full working order.

Up to the 31st of March last, the results of the system have been that constant supply is being given on two of the divisions at 16 and 18 gallons per head per day, the average for the population of 200,000 persons being 20·51 gallons, as compared with 35·09 gallons before Deacon's meters were introduced, and there can be no doubt that


LAMBE
WATER WORKS COM
1884
Prepared by
COLONEL SIR FRANCIS BOLTON, C.E.
Water Examiner "Metro Water Act 1871"
Kew
Isleworth
Richmond
Twickenham
Petersham
Southend
Teddington
Lock
Weir
Hampton
MOLESEY
River
Thames
Kingston
Surbiton
DITTON
Thames Ditton
Long Ditton
Hook
Mole
River
Claygate
3 MILES

ETH WATERWC

TABLE No. 7A.—Statement sh the Income, Expenditure c

s of COLONEL SIR FRANC

For Year ending	(at the end of each Year)				
	Share and Loan Capital authorised.	Ordinary Stocks and Shares.	oan d.	Balance of Authorised Capital remaining to be raised.	Cap
31st March,	£.	£.		£.	
1874	1,498,000	891,580		370,470	1
1875	1,498,000	953,650		311,000	1
1876	1,498,000	1,046,781		241,204	1
1877	1,450,000	1,107,987		146,048	1
1878	1,559,500	1,108,075		244,260	1
1879	1,559,500	1,108,075		212,580	1
1880	1,572,815	1,182,860		175,900	1
1881	1,573,088	1,226,667		137,366	1
1882	1,573,634	1,286,764		112,915	1
1883	1,574,180	1,312,909		87,316	1
Total . . .	...	...		...	

For Year ending,	Maintenance of Reservoirs, Filtering Beds, Works, and Pipes for Storing Water.	Maintenance of Mains, &c., Meters, and Works connected with Distribution, including Renewals.	Taxes.	Compensations, Premises and Mills; Superannuations and Law Expenses connected with Maintenance.	T
31st March,	£. s. d.	£. s. d.	s. d.		
1874	2,272 11 5	6,094 15 4	7 9	...	4
1875	2,038 0 1	6,103 5 1	5 2	...	4
1876	1,938 12 8	6,843 15 7	6 7	...	4
1877	1,526 11 3	7,514 19 6	4 7	...	4
1878	1,248 16 5	7,680 3 11	2 7	...	4
1879	2,019 13 4	10,414 19 11	3 2	...	4
1880	1,603 11 8	10,363 19 2	7 0	...	4
1881	1,752 8 2	12,367 2 4	9 9	...	5
1882	2,520 14 1	12,124 12 4	3 7	...	5
1883	3,614 5 0	12,376 13 10	8 5	...	5
Total. . .	20,535 4 1	91,884 7 0	8 7	...	47

For Year ending	Total Expenditure on Ma and Management	Net Profit.
31st March,	£. s. d.	£. s. d.
1874	48,113 6 7	51,138 9 5
1875	46,622 7 5	56,375 14 9
1876	48,613 3 2	61,642 16 6
1877	53,673 1 8	64,443 17 2
1878	51,841 11 11	71,659 2 5
1879	58,295 4 8	70,805 19 10
1880	58,616 6 2	77,795 4 2
1881	65,858 3 7	79,727 16 2
1882	68,472 10 5	87,504 18 10
1883	71,179 3 10	96,153 3 4
Total. . . .	571,284 19 5	717,247 2 7

when the new proposed constant supply districts are completed, and the meter system is extended to them, a still further reduction in the consumption will be effected, resulting in increased working pressure in the service pipes, which at present is about 94 feet, or 40 lbs. to the square inch, in the town district.

The average daily supply per head on the Company's whole district for the year ended March 31st last, was 29·85 gallons, as compared with 33·36 gallons, the mean average daily supply for the previous six years; while, as before stated, the present average consumption per head on the constant supply division amounts to 20·51 gallons. But the consumption can only be maintained at this low figure by continual inspection and supervision.

The present staff attending to this particular service consists of 1 superintendent, and 22 waste water inspectors (entailing an annual cost to the Company of about £2,300), who are exclusively employed on inspection of fittings and waste meters in the constant supply districts, and house to house inspection in the country districts, their whole time being occupied in preventing and suppressing waste. The staff have also to see that the prescribed fittings are provided, and that the Board of Trade regulations for avoiding contamination of the water supply are effectually carried out.

The Company have no wish to restrict the public in the legitimate use of water, but desire to provide an abundant supply and to encourage its use for all domestic and reasonable purposes, while taking measures to prevent actual waste.

Further statistical details relating to this Company's Works will be found in *Statistics of Supply, Table No. 7* (*ante*, facing page 504), and concerning its Capital, Income, Expenditure and profits, in *Table No.* 7A appended.

A map is also appended, showing the parliamentary boundaries of the Company, the position of the principal works, and direction of the mains, the district supplied, and the area under constant supply, which are distinguished by different shadings.

VIII.—THE CHELSEA WATERWORKS.

THE first charter of the Chelsea Company was granted in 1723, the 9th year of the reign of George I. In 1726 a royal warrant was granted, authorising the Company to convert two ponds in St. James's Park into reservoirs, and in 1727 another warrant was obtained authorising the construction of a reservoir in Hyde Park.

The original capital of the Company was £40,000.

The works were situated on the north bank of the Thames at Chelsea, the supply being drawn direct from the river, and in this state distributed to the consumers. The first attempt to purify the water was by allowing the impurities to subside in settling reservoirs, but this not proving effective, filter-beds were designed and constructed, in 1829, by the Company's engineer, the late Mr. Simpson. This method of purification has also been adopted by all the London Companies not taking their supply from wells.

Owing to the growth of London, and the increased contamination of the water of the River Thames, it became necessary to seek a supply above the influence of the tide; and in 1852 an Act was obtained for moving the site of the works and intake to Surbiton, adjoining the new works of the Lambeth Water Company.

The Chelsea Company's new works, completed in 1856, consisted of two subsidence reservoirs, two filter-beds, four engines of an aggregate power of 600 horses, and a thirty-inch main to Putney Heath, where covered reservoirs were constructed with a capacity of about ten million gallons; whence the water was distributed to the district. An open reservoir was also constructed for the unfiltered water then used for road-watering. The distributing mains are carried

across the river by an aqueduct a little above Putney Bridge.

By the same Act (1852) the Company were authorised to increase their capital from £300,000, at which it then stood, by the issue of £440,000 fresh capital. By their Act of 1864 they were authorised to raise an additional share capital of £328,750.

The periodical and increasing turbidity of the water caused by the floods from the river Mole, which flows into the Thames above the works at Surbiton, induced the Company in 1875 to apply for and obtain parliamentary powers, to remove their intake to a point higher up the river above the influence of the Mole and about half a mile below Sunbury Lock. By this Act (1875) the Company were authorised to raise further capital to the extent of £200,000. The total capital of the Company authorised by the various Acts of Parliament is £1,268,750.

The Company have now three stations, viz.:

1. Walton and West Molesey.
2. Surbiton.
3. Putney Heath.

1. *Walton and West Molesey.* The intake, on the south bank of the Thames, in the parish of Walton. The water has first to pass through an iron grating at the intake (guarded by a moveable wooden screen, so arranged as to prevent any accumulation of leaves and weeds from being drawn through the grating), and then through double fine wire screens into the covered wells, from which the water is pumped into the "regulating tank" (a lift of about 20 feet) by means of two steam engines, each of about 50 horse-power. From the "regulating tank" the water runs into any one of the four subsidence reservoirs. Each of these is capable of holding at least 35,000,000 gallons, the capacity of the four being 140,000,000: or, if necessary, the water can be delivered into the 36-inch conduit pipe and sent direct from the intake on to the filters at Surbiton, a distance of nearly five miles.

These additional works, which were constructed at a cost of £204,438, were brought into operation at the end of the year 1877.

2. *Surbiton*. Here the water is received from West Molesey for the purpose of undergoing the process of filtration. The filter-beds, originally two in number with an area of two acres, with 2 reservoirs of 3 acres area, were extended subsequently, and the reservoirs converted into filters, the latter being now 7 in number and the area $6\frac{3}{4}$ acres. Four or five of these are usually in operation at one time, the remainder being cleaned by the removal of the top layer of sand, which is washed, dried, and replaced.

The filtering medium is 8 feet in depth, and consists of 4 feet 6 inches of sand, coarse and fine, 3 inches of shells, and 3 feet 3 inches of stones of various sizes.

The water, after passing slowly through the filters, flows into the engine wells, whence it is lifted by pumps of the bucket and plunger description worked by compound engines of 150 horse-power each. These engines, originally four in number, were increased in 1866 to six, having an aggregate power of 900 horses. Foundations, and other preparatory works have also been provided for an additional pair of engines when necessary.

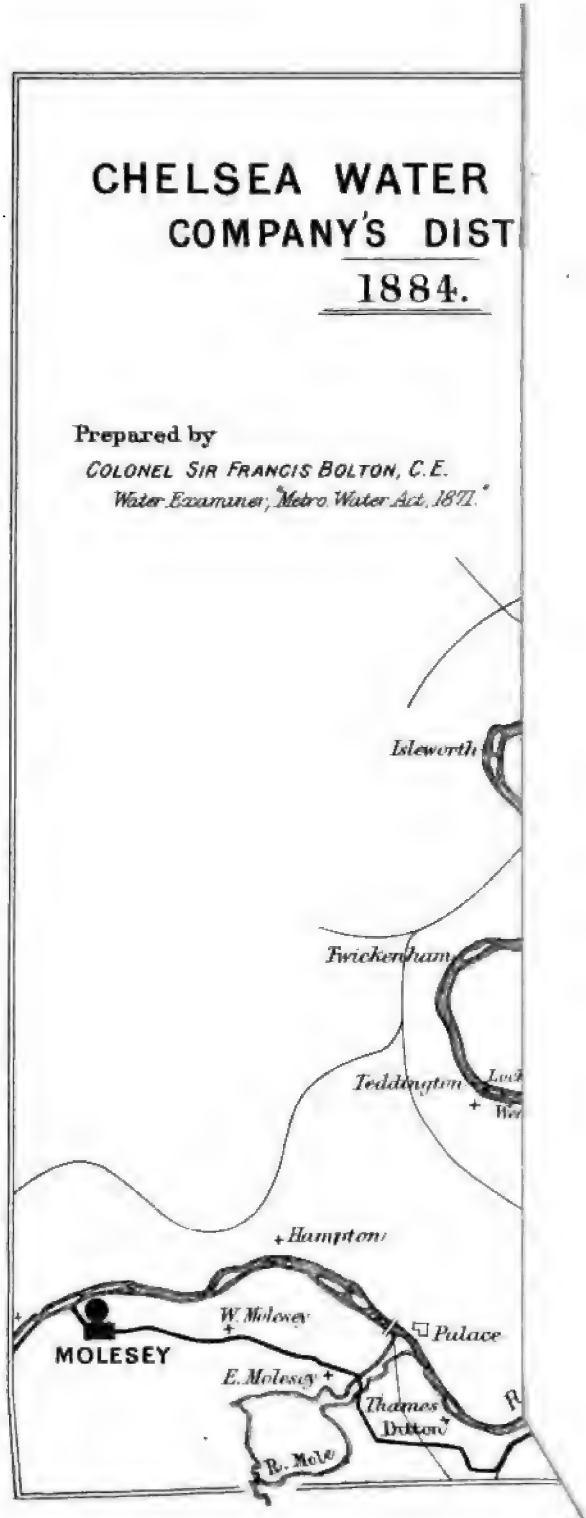
The existing engines are contained in two separate houses, and are fed with steam from 20 boilers.

A separate pair of engines of 50 horse-power formerly pumped a supply of unfiltered water for road-watering purposes. This system was abandoned in 1870, when it was found more economical to supply none but filtered water.

A smaller engine is used for drainage purposes.

These works also comprise a length of river wall, hydraulic machinery for unloading and storing coal, extensive workshops, coal store, offices, workmen's cottages, &c.

The filtered water is pumped by the engines already described up to the service reservoirs on Putney Heath, a distance of over five miles, through 3 lines of pipes, viz. two



CHELSEA WATER
COMPANY'S DIST
1884.
Prepared by
COLONEL SIR FRANCIS BOLTON, C.E.
Water Examiner, "Metro. Water Act, 1871."
Isleworth
Twickenham
Teddington
Hampton
W. Molesey
MOLESEY
Palace
E. Molesey
Thames
Ditton
R. Mole

EA WATERW

TABLE No. 8A.—Statement shoe, Expenditure on Mai

LONEL SIR FRANCIS

For Year ending	Share and Loan Capital authorised.	Ordinary Stocks and Shares.	ce of Authorised al remaining to be raised.	Capital ex
			end of each Year).	
31st March,	£.	£.	£.	£.
1874	1,068,750	615,600	190,810	896,6
1875	1,068,750	615,600	138,593	921,7
1876	1,268,750	615,600	211,050	1,027,0
1877	1,268,750	615,600	155,470	1,093,0
1878	1,268,750	615,600	112,550	1,126,7
1879	1,268,750	615,600	116,050	1,140,1
1880	1,268,750	615,600	116,050	1,146,4
1881	1,268,750	615,600	116,050	1,149,1
1882	1,268,750	615,600	116,050	1,151,1
1883	1,268,750	680,065	118,050	1,153,5
Total . . .	...	...	...	...

For Year ending	Maintenance of Reservoirs and Works for Storing Water.	Maintenance of Mains and Works connected with Distribution.	Compensations, Premises and Mills; Superannuation and Law Expenses connected with Maintenance.	Tota te
31st March,	£. s. d.	£. s. d.		£.
1874	...	2,882 11 7	...	22,28
1875	...	3,971 18 11	...	22,22
1876	316 13 2	4,856 19 7	...	22,46
1877	354 16 8	3,699 4 8	...	21,26
1878	986 11 1	4,088 10 1	...	24,30
1879	1,412 7 8	5,218 15 11	...	28,12
1880	1,381 1 10	4,115 14 11	...	25,83
1881	1,464 7 8	5,004 14 8	...	28,04
1882	1,368 13 9	4,127 14 10	...	27,03
1883	1,418 15 10	3,387 16 9	...	25,98
Total . .	8,703 7 8	41,354 1 11	...	247,56

For Year ending	Total Maintenance and Net Profit.	
31st March,	£. s.	£. s. d.
1874	29,558 13	156 4 6
1875	28,841 12	178 16 6
1876	29,364 4	343 18 0
1877	28,434 1	763 17 8
1878	31,826 18	512 13 5
1879	36,073 8	196 3 0
1880	33,248 3	901 17 1
1881	36,000 0	189 2 3
1882	35,065 2	929 3 8
1883	33,865 19	188 8 1
Total	322,278 4	360 4 2

lines of 30 inches and one of 15 inches diameter, the lift being to an elevation of 180 feet above the engine wells.

3. *Putney Heath.* This station consists of three service reservoirs with a joint capacity of 11,000,000 gallons. One of these reservoirs, originally an open one, designed to contain the unfiltered water formerly used for road-watering, was, after the discontinuance of that system, arched over and used for the high-service supply of the district. The reservoirs are situated at an elevation of 185 feet above Ordnance datum.

From Putney Heath the water flows by gravitation through four mains, two of 24 inches diameter and two of 12 inches diameter, into the district, crossing the Thames by an aqueduct a little above Putney Bridge. This aqueduct is now being removed to give place to the new granite bridge in course of erection by the Metropolitan Board, a temporary aqueduct having been constructed alongside old Putney Bridge to carry the Company's pipes pending the construction of the new bridge, across which the pipes will be eventually laid, under the footways.

Though not one of the largest, this is one of the most important districts in London.

The total length of mains and pipes laid by this Company amounts at the present date to about 215 miles.

Further statistical details relating to this Company's Works will be found in *Statistics of Supply*, *Table No.* 8 (*ante*, facing page 504), and concerning its Capital, Income, Expenditure, and Profits, in *Table No.* 8A appended.

A map is also appended, shewing the parliamentary boundaries of the Company, the position of the principal works, and direction of the mains, the district supplied being distinguished by shading.

THE OLD LONDON BRIDGE WATERWORKS.

While these pages were in the press the following interesting article appeared in the *St. James's Gazette*, descriptive of the Old London Bridge Waterworks, which were absorbed by the New River Company, as already mentioned (p. 560, *supra*) :—

With a population of some five millions seated upon its banks, it is not wonderful that the condition of the Thames should be a subject of surpassing interest and importance. The present may be regarded as not the least important epoch in its history; and the multitude of views and opinions put forward as to the best mode of freeing the river, decisively and for all time, from the deteriorating influences that now beset it are as remarkable for their variety as for the vigour with which each from its own point of view is advocated. Similar vigour, however, has never been wanting in prior discussions of the like kind; and it may be interesting at the moment to recur to an almost forgotten chapter in the river's history, the picturesque facts of which are entitled to be much more widely known than appears from some unexplained cause to be the case.

Before Myddelton, in 1608, began his important work of bringing the New River from Chadwell and Amwell to London, the water supply of the City was alike indequate and ill arranged. The citizens were not without established sources to look to: certain "conduits" and wells existed within the civic boundaries; but their service seems to have been so irregular and insufficient, that the bulk of the water for domestic requirements was still procured by the primitive method of fetching it in buckets from the river. The numerous lanes running down to its bank greatly facilitated this operation: which, however, towards the end of the sixteenth century struck an ingenious Dutch engineer, "denizen of London," as being so unworthy of the citizens that he set to work upon a scheme to remedy it. This was forty years before the drainage of the Fen district by Vermuyden had brought Dutch engineers into notice; but Master Peter Morrys was so favourably known that he was enabled in 1582 to present his

scheme to the Corporation. His idea was a simple one, and by its adoption the City was in fact largely supplied with water for nearly 250 years afterwards. It consisted of a system of water-wheels, to be erected in certain of the nineteen arches of which "old" London Bridge was composed; and which, worked by the power of the tides, were to pump the river-water to a height sufficient for its subsequent distribution through pipes. This was the plan eulogized by Stow as being of "great convenience and no small profit to the City;" though, as regards the latter result, it may be believed that it served the projector and his family even better than it did his neighbours. At all events, impressed with the feasibility of the idea, the Corporation granted Morrys a lease of the first arch on the City side for a term of five-hundred years, at the rent of 10*s.* per annum; and two years afterwards the second arch was granted on similar terms. More than a hundred years passed before (in 1701) another arch was leased to a grandson of the original inventor; and at this time the proprietary rights of the concern were disposed of to one Richard Soams, a goldsmith, for the considerable sum of £36,000. The latter converted the undertaking into a company, by dividing the property into 300 shares of £500 each; and that its prosperity continued may be concluded from the fact that, in 1761, yet another arch of the bridge, the fourth, was granted to the existing proprietors.

These gradual encroachments upon the tidal way were not universally regarded with the same equanimity. On the contrary, they were the subjects of constant disputes and petitions; and, as may be imagined, the wharfingers and lightermen made bitter complaint of the dangereus eddies occasioned by the obstructions —two other archways having also been closed to give additional power to the water-works. At its best the actual water-way under the old bridge bore an absurdly small proportion to the width of the river. This was still further contracted by the immense platforms ("sterlings") built round the piers, which so dammed up the water at the return of the tide that the river above the bridge was then about five feet higher than it was below. During the ebb the water came down with a rush, and was in fact converted into so many "rapids," the shooting of which demanded considerable skill, and was never unattended with risk. Advocates for the existing state of things were not, however, wanting; and among the pleas put forward was one which bears a curious resemblance to that which has been heard in connection with

the present difficulties between Isleworth and Teddington. It was "that the bridge was originally so constructed as to restrain the ebbing of the tide and preserve the navigation of the river above it; and that if the arches were widened the tide would ebb away so fast that there would be scarcely any navigation above the bridge a little after high water."

Notwithstanding the unquiet period upon which the works seem now to have entered, the proprietors were not lacking in confidence. In 1767 they presented a petition to the Committee for Letting the City lands; which—after setting forth the facts of the previous grants, and that the petitioners were even yet unable to furnish sufficient water—made application for a lease of another (the fifth) arch of the bridge, by which, and the use of their fire-engine, the company "humbly apprehended they should be enabled, not only to supply the common exigencies of their tenants, but also the extraordinary demands for water whenever the dreadful calamities of fire should require it." Strange as it may appear, the lease was granted; but only after a hot discussion, and under the express condition that, if it should be found prejudicial to the navigation of the river, the Corporation should be at liberty to revoke it. The most eminent engineers of the day (including Smeaton and Brindley) were consulted in the matter; and the result was that the first five arches of the bridge were occupied with a series of immense water-wheels; and the two central archways, which had been for some time closed, having been again thrown open, wheels were also placed in the two arches at the south end.

It would be tedious to attempt a minute description of the machinery of these extensive works. That it was remarkably good of its kind is certain enough; though it was of course variously modified during its long period of service. Smeaton himself designed an improved kind of wheel after the grant of the fifth arch; and the sight of the entire apparatus worked by a strong tide was without doubt an imposing one. The wheels were of the kind technically known as "undershot;" that is to say, the water flowed beneath them, the momentum only of the current being utilized. The axles of each series were 19 feet in length and 3 feet in diameter; their "bearings" being so arranged as to be adjustable to the proper level of the tide. Over 2,000 gallons of water were raised to a height of 120 feet every minute by the united power of the whole; and shortly before their removal it was stated before a Committee of the House of Commons that

in the year 1820 the works had delivered 26,000,000 hogsheads of water for the use of the citizens. In all, ten separate sets of main-pipes were thus supplied; the Bishopsgate main by the wheels under the third and the western end of the fourth arch; Cheapside main from the wheels under the second and third arches; while the remaining wheels were connected with the Aldgate, Fleet-street, Newgate-street, and other mains adjacent. These were the most imperfectly constructed portions of the machinery; and the bridge itself sustained much damage—it was, in fact, always under repair—from the constant leakage of the numerous pipes laid across it. Its safety, and the interests of the waterworks, had been long declared to be so diametrically opposite, that the one must prove the absolute ruin of the other.

But the time was at hand when the old order of things was to give place to the new. In 1817 the proprietors, still energetic in the prosecution of their business, gave notice according to the terms of their holding that they were about to rebuild their largest water-wheel—a design, however, which was never to be carried into effect. In 1822 an Act of Parliament was passed for the entire removal of the works, and for the very necessary erection of a new bridge. The old one had stood for over six centuries, and had given shelter to the ponderous wheels beneath it for 240 years. In that period they had performed no despicable service; and, judged by the standand of the time, their work is yet entitled to the approval of posterity.

APPENDIX I.

MEMORANDUM

As to the Duties and Powers of the Local Government Board under the enactments applicable to the Metropolis Water Supply.

This memorandum comprises a statement of the effect of certain statutory provisions which relate to the Water Supply of the Metropolis and impose duties or confer powers upon the Local Government Board.

The method adopted in the preparation of the statement has been to reproduce, as far as possible, the language of the several statutes in an abbreviated form, to include the substance of all provisions which show the nature of the incidents and consequences of the action of the Board, and to add such definitions as are necessary to indicate the scope of that action and the particular authorities and administrative areas affected by it.

The contents of the divisions and subdivisions of the text are summarised in head-notes printed in italics, and references to the Acts and sections from which the text has been compiled are in every case appended.

WATER.

(*a.*) New Sources of Supply.

Company to give Notice to Board before resorting to new Sources.

Three months before resorting to a new source of supply, a company supplying the Metropolis or any part thereof with water for domestic use must give notice to the Board.

Appointment of Inspector to report on existing and new Sources.

Within one month after receipt of the notice, the Board, if they think fit, shall appoint an inspector to report with respect to sources then specially authorised by Parliament, whether the directions of the special Act, *i.e.* every Act relating to the company, have been complied with in reference thereto, and with respect to new sources not specially authorised by Parliament, whether they are capable of supplying good and wholesome water for domestic purposes.

Board to certify Approval or Disapproval of Sources, &c.

The Board, within 21 days after the receipt of the inspector's report, must send to the company with respect to any such new sources a certificate of approval or disapproval, and, with respect to any such sources then specially authorised by Parliament, a notice, stating whether in the judgment of the Board the directions of the special Act have in reference thereto been complied with.

If Board disapprove, Company not to use Sources.

After receiving a certificate of disapproval of any such new source the company must not use the source, and after receipt of notice that in the judgment of the Board the directions of the special Act with reference to any sources then specially authorised by Parliament have not been complied with, the company, before complying with those directions, must not use those sources.

(15 & 16 *Vict. c.* 84. *ss.* 5, 7, *and* 8; 38 & 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

(*b.*) Inquiries as to Quantity and Quality of Water.

On complaint as to Quantity and Quality of Water, Board may appoint a Person to inquire and report.

If complaint as to the quantity or quality of the water supplied by a company for domestic use be made to the Board by memorial signed by not less than 20 inhabitant householders paying rents for and supplied with water by the company, the Board, within one month after the receipt of the complaint, may appoint a competent person to inquire into the grounds of such complaint, and to report to them thereon.

If Complaint appears well founded, Board to give Notice to Company.

If after receipt of the report it appears to the Board that the complaint is well founded, they must give notice thereof to the company.

Company to remove Grounds of Complaint.

After the receipt of the notice the company must within a reasonable time remove the grounds of the complaint.

(15 & 16 *Vict. c.* 84. *ss.* 9, 12, *and* 13; 38 & 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

Board empowered to appoint Person to inquire into and report on Quality of Water.

The Board may at any time appoint a competent person to inquire into and report on the quality of the water furnished by a company, notwithstanding that no complaint has been made by inhabitant householders.

The provisions of the *Metropolis Water Act*, 1852, are to apply as if the person were appointed under Section 9 of that Act, and as if any matter reported to the Board as requiring alteration on the part of the company had been the subject of a complaint by householders.

(34 & 35 *Vict. c.* 113. *s.* 35; 38 & 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

Appointment, Duties, and Remuneration of Water Examiner.

A water examiner, being a competent and impartial person, is to be from time to time appointed and removable by the Board.

The water examiner from time to time, in such manner as the Board direct, must examine the water supplied by any company to ascertain whether or not the company have complied with Section 4 of the *Metropolis Water Act*, 1852, *i.e.*, as to effectual filtration, and must report to the Board the results of his examinations.

The Board must send a copy of every report to the company to which it relates.

The companies must pay the water examiner such remuneration and in such proportions as the Board appoint.

(34 & 35 *Vict. c.* 113. *s.* 36; 38 & 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part. III.*)

(*c.*) Constant Supply.

Appeal to Board on Requisition or Proposal for Constant Supply.

When application has been made to a company requiring it to provide a constant supply, or when a company has given notice to a metropolitan authority of a proposal to give a constant supply in any district, and the company or the authority object to the requisition or proposal, the company or authority within one month after the making of the application or service of the notice may present a memorial to the Board, setting forth the objections to the requisition or proposal.

The Board, as soon as conveniently may be after the receipt of the memorial, must take it into consideration, and may institute an inquiry in relation thereto, and may hear the company and authority desiring to be heard, and may make such order in reference thereto and as to the costs thereof and incident to the same as to them seems just.

(34 & 35 *Vict. c.* 113. *s.* 9; 38 & 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

Board empowered to require Constant Supply.

The Board may require a constant supply to be provided in any district by the company within whose limits the district is situate, upon complaint and in case it appears to the Board after due inquiry,—

That the metropolitan authority refuse to make or unreasonably delay making application for the constant supply; or

That by reason of the insufficiency of the existing supply, or the unwholesomeness of the water in consequence of its being improperly stored, the health of the inhabitants is or is likely to be prejudicially affected.

(34 & 35 *Vict. c.* 113. *s.* 11; 38 & 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

Board empowered to extend Time for Works.

Where a constant supply is required and the company is unable to execute all the necessary works within the time prescribed by the Act, the Board may extend the time for the giving of the supply generally, or may extend the time and direct the supply to be given at different times in succession to the several parts of the district in such manner as may be found most convenient.

Application by the company for the extension of time must be made within one month after notice requiring a constant supply has been served upon them.

(34 & 35 *Vict. c.* 113. *s.* 13; 38 & 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

Provision on order of Board for Supply in Courts, &c.

If it appears to the Board, on the report of the nuisance authority, that a constant supply cannot be well and effectually provided for a group or number of dwelling-houses in a court or passage, or otherwise in contiguity with or in close neighbourhood to one another, except by means of a stand-pipe or other apparatus placed outside the dwelling-houses, the Board may order the group or number of dwelling-houses to be so supplied, and they must serve their order on the company within whose limits the houses are situate.

If there is more than one owner of the dwelling-houses, the expense of providing the stand-pipe or other apparatus is to be borne by the respective owners in such proportions as the Board direct.

The Board may at any time abrogate, wholly or in part, the order, or may originally grant it only for a limited period.

(34 & 35 *Vict. c.* 113. *s.* 14; 38 & 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

(*d.*) Regulations.

Company at request of Board may repeal or alter Regulations.

A company, if it thinks fit, or if requested by the Board, may repeal or alter any of the regulations made for preventing the waste or misuse, undue consumption or contamination of water, or may make new regulations.

Board may appoint Person to report and may make Regulations.

In case a company, on being requested by the metropolitan authority, or by any 10 consumers of the water supplied by the company, to repeal or alter any regulations in force or to make new regulations, refuses to do so, the Board may appoint a competent and impartial person of engineering knowledge and experience to report to them as to such regulations as may be necessary, or as to the expediency of altering or repealing such regulations, or of

making new regulations in conformity with the request of the authority or consumers, and on his report the Board may make such regulations, repeal, or alterations as they think fit.

Penalties for Offences against Regulations.

Regulations may impose penalties for offences not exceeding in respect of any offence the sum of 5*l.*

Regulations to be confirmed by Board.

No regulation, repeal, or alteration of a regulation made by a company is to be of any force unless and until it is submitted to and confirmed by the Board.

Inquiry by Board as to Regulations.

They may institute such inquiry as they think fit, and at the inquiry must hear the metropolitan authority and the company, if desiring to be heard. The Board, if they think fit, or if requested, must nominate and have present at the inquiry to advise and assist them a competent and impartial waterworks engineer.

The Board may, after the inquiry, confirm or disallow any regulation, repeal, or alteration in whole or in part, or may confirm it with a modification or alteration.

No regulation, repeal, or alteration is to be made by the Board except after a like inquiry and hearing, with the like advice and assistance.

Notice to be given before Confirmation.

No regulation, repeal, or alteration is to be confirmed or made by the Board unless notice has been given by the company or by such person as the Board direct in the *London Gazette*, and in two daily morning newspapers circulated within the limits of the *Metropolis Water Act*, 1871, one month at least before the inquiry.

Copies to be deposited for Inspection.

A copy of the regulation, repeal, or alteration is to be sent by the company or person one month at least before the inquiry to the office of the metropolitan authority, and for one month it is to be kept open during office hours at the offices of the authority and

of the company to the inspection of all persons without fee or reward, and a copy of it, or of any part of it, is to be furnished to every person who applies, on payment of 6*d.* for every 100 words in the copy.

(34 *&* 35 *Vict. c.* 113. *ss.* 18, 19, 20, *and* 22; 38 *&* 39 *Vict. c.* 55. *s.* 343, *Sch. V. Part III.*)

(*e.*) Prescribed Fittings.

Notice by Company to Owner or Occupier to supply Premises with Fittings.

Where a company is required or has proposed to provide a constant supply, the company, after the expiration of one month after the publication in the *London Gazette* of a copy of the notice requiring or proposing the constant supply, unless a memorial or application has been presented or made to the Board objecting to the constant supply or seeking an extension of time, and if any such memorial or application has been presented or made, then, at such time after the determination of the Board in relation to the memorial or application as they approve and order, may cause to be served on the owner or occupier of any premises a notice requiring them to supply the premises with the prescribed fittings.

Appointment by Board of Person to enter Premises for inspection or repair of Fittings.

Where a company is required or has proposed to provide a constant supply, a person appointed by the Board may at all reasonable times enter any premises to inspect and examine them with a view to ascertain whether there are in or about them the prescribed fittings, or, where authorised, to provide or repair the fittings.

(34 *&* 35 *Vict. c.* 113. *ss.* 27 *and* 30; 38 *&* 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

(*f.*) Accounts and Audit.

Annual Accounts in prescribed Form to be forwarded to Board.

Every company, on or before the 31st of July in every year, must fill up and forward to the Board a statement of account made up to the end of its financial year then last passed, in such

form and containing such particulars as may from time to time be prescribed by the Board.

A company making default is liable to a penalty not exceeding 10*l.* for each day during which the default continues.

Appointment and Remuneration of Auditor.

An auditor of the accounts of the companies, being a competent and impartial person, is to be from time to time appointed and removable by the Board.

The companies must pay the auditor such remuneration and in such proportions as the Board appoint.

(34 *&* 35 *Vict. c.* 113. *ss.* 37 *and* 38; 38 *&* 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

(*g.*) Penalties.

Penalties on Companies for Non-compliance with Statutory Provisions.

A company violating, refusing, or neglecting to comply with any of the provisions in Sections 1–14 of the *Metropolis Water Act*, 1852, is to forfeit to Her Majesty the sum of 200*l.*, and the further sum of 100*l.* for every month during which it continues to violate or to refuse or neglect to comply with the same after receiving notice from the Board to discontinue such violation, refusal or neglect.

(15 *&* 16 *Vict. c.* 84, *s.* 16; 38 *&* 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

A company violating, refusing, or neglecting to comply with any of the provisions in Sections 1–15 of the *Metropolis Water Act*, 1871, is liable to a penalty not exceeding 200*l.*, and to a further penalty not exceeding 100*l.* for every month during which the violation, refusal, or neglect continues after the company has received notice from the Board to discontinue such violation, refusal, or neglect.

(34 *&* 35 *Vict. c.* 113. *s.* 16; 38 *&* 39 *Vict. c.* 55. *s.* 343, *Sch. V., Part III.*)

(*h.*) Definitions.

Meaning of "Metropolitan Authority," "Nuisance Authority," and "Metropolis."

"Metropolitan authority" means, as regards the City of London

and its liberties, the mayor, aldermen, and commons of the City of London, and, as regards the Metropolis, except the City of London and its liberties, the Metropolitan Board of Works.

(34 & 35 *Vict. c.* 113, *s.* 2, *Sch. A.* 38 & 39 *Vict. c.* 55. *s.* 343, *Sch. V.*, *Part III.*)

"Nuisance authority" means, as regards the City of London and its liberties, the Commissioners of Sewers, and, as regards the Metropolis (*exclusive of the City of London and its liberties*), the vestry or district board under the *Metropolis Management Act*, 1855.

(23 & 24 *Vict. c.* 77. *ss.* 2 *and* 6; 29 & 30 *Vict. c.* 90. *s.* 15; 34 & 35 *Vict. c.* 113. *s.* 14.)

"Metropolis" means the Metropolis as defined by the *Metropolis Management Act*, 1855.

(34 & 35 *Vict. c.* 113. *s.* 3.)

Limits of Metropolis Water Acts.

The limits within which the provisions of the *Metropolis Water Act*, 1852, and the *Metropolis Water Act*, 1871, are in force include the Metropolis.

(34 & 35 *Vict. c.* 113. *ss.* 2 *and* 4.)

RATES OF SUPPLY.

I.—KENT WATERWORKS COMPANY.

The following charges are authorised to be made by the Kent Waterworks Company (*vide* Kent Waterworks Act, 1864) :—

28. The company shall, at the request of the owner or occupier of any house or part of a house in any street in which from time to time any pipe of the company is laid, or of any person who, under the provisions of this Act, is entitled to demand a supply of water for domestic purposes, furnish to him a sufficient supply of water for domestic purposes, at rates not exceeding the following (that is to say),

Where the yearly value of the house supplied does not exceed seven pounds, eight shillings :

Where it exceeds seven pounds and does not exceed eight pounds, nine shillings and sixpence :

Where it exceeds eight pounds and does not exceed nine pounds, ten shillings and sixpence :

Where it exceeds nine pounds and does not exceed ten pounds, twelve shillings :

Where it exceeds ten pounds and does not exceed eleven pounds, thirteen shillings :

Where it exceeds eleven pounds and does not exceed twelve pounds, fourteen shillings :

Where it exceeds twelve pounds and does not exceed thirteen pounds, fifteen shillings and sixpence :

Where it exceeds thirteen pounds and does not exceed fourteen pounds, sixteen shillings and sixpence :

Where it exceeds fourteen pounds and does not exceed fifteen pounds, eighteen shillings :

Where it exceeds fifteen pounds and does not exceed sixteen pounds, nineteen shillings :

Where it exceeds sixteen pounds and does not exceed seventeen pounds, one pound :

Where it exceeds seventeen pounds and does not exceed eighteen pounds, one pound one shilling and sixpence:

Where it exceeds eighteen pounds and does not exceed nineteen pounds, one pound two shillings and sixpence:

Where it exceeds nineteen pounds and does not exceed twenty pounds, one pound and four shillings:

Where it exceeds twenty pounds and does not exceed twenty-five pounds, one pound and eight shillings:

Where it exceeds twenty-five pounds and does not exceed thirty pounds, one pound and eleven shillings:

Where it exceeds thirty pounds and does not exceed thirty-five pounds, one pound and fifteen shillings:

Where it exceeds thirty-five pounds and does not exceed forty pounds, two pounds:

Where it exceeds forty pounds and does not exceed forty-five pounds, two pounds and five shillings:

Where it exceeds forty-five pounds and does not exceed fifty pounds, two pounds and ten shillings:

Where it exceeds fifty pounds and does not exceed sixty pounds, two pounds and fifteen shillings:

Where it exceeds sixty pounds and does not exceed seventy pounds, three pounds and three shillings:

Where it exceeds seventy pounds and does not exceed eighty pounds, three pounds and ten shillings:

Where it exceeds eighty pounds and does not exceed ninety five pounds, three pounds and sixteen shillings:

Where it exceeds ninety-five pounds, at a rate not exceeding four pounds *per centum per annum* on the yearly value.

29. A supply of water for domestic purposes includes a supply of water for one water-closet, but not a supply of water for more than one water-closet, or for any bath, and does not include a supply of water for cattle or for horses, or for washing carriages, if the horses or carriages are kept for hire, or by common carriers, or are the property of a dealer, or for steam engines, or for railway purposes, or for warming or ventilating purposes, or for working any machine or apparatus, or for any trade, manufacture, or business, whatsoever, or for watering gardens by means of any tap, tube, pipe, or other like apparatus, or for fountains, or for flushing sewers or drains, or for public baths, or for any ornamental purpose whatever.

30. The company may charge for every year, in respect of every water-closet more than one, and every bath, in any dwelling

house, in addition to the ordinary yearly rates, any rates not exceeding the following yearly rates (that is to say),

Where the yearly value of the dwelling house does not exceed nine pounds, five shillings for every water-closet more than one, and six shillings for every bath:

Where the yearly value of the dwelling house exceeds nine pounds and does not exceed twenty pounds, six shillings for one water-closet beyond the first, and eight shillings for one bath, and five shillings for every additional water-closet, and six shillings for every additional bath:

Where the yearly value of the dwelling house exceeds twenty pounds and does not exceed forty pounds, seven shillings for one water-closet beyond the first, and ten shillings for one bath, and five shillings for every additional water-closet, and six shillings for every additional bath:

Where the yearly value of the dwelling house exceeds forty pounds and does not exceed sixty pounds, eight shillings, for one watercloset beyond the first, and ten shillings for one bath, and five shillings for every additional watercloset and six shillings for every additional bath:

Where the yearly value of the dwelling house exceeds sixty pounds and does not exceed eighty pounds, eight shillings for one watercloset beyond the first, and twelve shillings for one bath, and five shillings for every additional water-closet, and six shillings for every additional bath:

Where the yearly value of the dwelling house exceeds eighty pounds, ten shillings for one water-closet beyond the first, and twelve shillings for one bath, and five shillings for every additional water-closet, and six shillings for every additional bath.

II.—New River Waterworks Company.

The following charges are authorised to be made by the New River Waterworks Company (*vide* New River Company's Act, 1852):—

XXXV. That the company shall, at the request of the owner or occupier of any house or part of a house in any street within their limits in which any pipe of the company shall be laid, or of any person who, under the provisions of this Act or any Act incorporated therewith, shall be entitled to demand a supply of

water for domestic purposes, furnish to such owner or occupier or other person a sufficient supply of water for domestic purposes at the rates hereinafter specified (that is to say),

For water supplied to any dwelling house :

Where the annual value of the dwelling-house shall not exceed two hundred pounds, at a rate *per centum per annum* on such value not exceeding four pounds :

Where such annual value shall exceed two hundred pounds, at a rate *per centum per annum* on such value not exceeding three pounds :

If there be a water-closet or water-closets, or fixed bath or baths, or any high service in such dwelling-house or place, then, in addition to the rates above specified, the following rates shall be payable (that is to say),

Where the annual value of such house shall exceed thirty pounds but shall not exceed fifty pounds, a rate not exceeding four shillings *per annum* for each single water-closet, fixed bath, or high service, and a further sum of two shillings for each additional water-closet, fixed bath, or high service :

Where such annual value shall exceed fifty pounds but shall not exceed one hundred pounds, a rate not exceeding six shillings *per annum* for each single water-closet, fixed bath, or high service, and a further sum of three shillings for each additional water-closet, fixed bath, or high service :

Where such annual value shall exceed one hundred pounds, but shall not exceed two hundred pounds, a rate not exceeding eight shillings for each single water-closet, fixed bath, or high service, and a further sum of four shillings for each additional water-closet, fixed bath, or high service :

Where such annual value shall exceed two hundred pounds but shall not exceed three hundred pounds, a rate not exceeding ten shillings for each single water-closet, fixed bath, or high service, and a further sum of five shillings for each additional water-closet, fixed bath, or high service :

And where such annual value shall exceed three hundred pounds, a rate not exceeding twelve shillings for each single water-closet, fixed bath, or high service, and a further sum of six shillings for each additional water-closet, fixed bath, or high service.

XXXVI. That the expression "high service" in this Act shall

mean and be considered as being a delivery of water at an elevation more than ten feet above the ground floor of such dwelling-house or other place supplied.

XXXVII. Provided, That with respect to all service which shall be given at an elevation of more than one hundred and sixty feet above *Trinity* high-water mark it shall be lawful for the company to charge, in addition to the rates hereinbefore authorised, a further sum not exceeding one pound *per centum per annum* on the annual value of such dwelling-houses respectively.

XXXVIII. That a supply of water for domestic purposes shall not include a supply of water for steam engines or railway purposes, or for warming or ventilating purposes, or for working any machine or apparatus, or for baths, horses, cattle, or for washing carriages, or for gardens, fountains, or ornamental purposes, or for flushing sewers or drains, or for any trade or manufacture or business requiring an extra supply of water.

XXXIX. That the company may, notwithstanding the provisions of this Act or any Act incorporated therewith, take an increased rate or charge by agreement with the person or body requiring a supply of water, and notwithstanding the same may exceed the rates or charges herein specified.

XL. That the company may supply any person or body within their limits with water, to be used within such limits for other than domestic purposes, at such rates and upon such terms and conditions as shall be agreed upon between the company and the person or body requiring such supply.

XLI. That the company shall, at the request of any consumer of water for purposes other than the purposes for or in respect of which the rates or charges are hereinbefore provided or limited, or at their own instance, afford a supply of water by means of a meter or other instrument or mode for measuring and ascertaining the quantity of water so supplied, and may charge for such supply not exceeding the following rates *per* one thousand gallons (that is to say),

When the quarterly consumption of water shall not exceed fifty thousand gallons, sevenpence halfpenny:

When exceeding fifty thousand gallons and not exceeding one hundred thousand gallons, sevenpence:

When exceeding one hundred thousand gallons and not exceeding two hundred thousand gallons, sixpence halfpenny:

When exceeding two hundred thousand gallons, sixpence :
And a further rate not exceeding twenty-five pounds *per centum* in respect of water so supplied at an elevation of more than sixty feet above *Trinity* high-water mark.

III.—East London Waterworks Company.

The following charges are authorised to be made by the East London Water Company (*vide* East London Waterworks Act, 1853):—

LXXII. That a supply of water for domestic purposes shall not include a supply of water for steam engines or railway purposes, or for warming or ventilating purposes, or for working any machine or apparatus, or for horses or cattle, or for washing carriages, or for gardens, fountains, or ornamental purposes, or for flushing sewers or drains, or for any trade or manufacture or business requiring an extra supply of water, or, as regards any house of which the annual value does not exceed thirty pounds, a supply of water for baths.

LXXIII. That the expression "ordinary service" in this Act means water delivered at an elevation not higher than twenty feet above the level of the pavement adjoining or nearest to the dwelling-house or other place supplied; and the expression "high service" in this Act means water delivered at an elevation exceeding twenty feet above the level of the pavement adjoining or nearest to the dwelling-house or other place supplied.

LXXIV. That the company shall, at the request of the owner or occupier of any house or of any part of a house occupied as a separate tenement in any street within their limits in which any main or service pipe of the company is or shall be laid, or of any person who under this Act shall be entitled to demand a supply of water for domestic purposes, furnish to such person, by means of communication pipes and other necessary and proper apparatus to be provided, laid down, and maintained at the cost of such person, a sufficient supply of water for his domestic purposes at a rate *per centum per annum* on the annual value of the house not exceeding five pounds.

LXXV. Where the annual value exceeds thirty pounds, an additional rate not exceeding four shillings *per annum* for every single watercloset and for every single fixed bath:

Where the annual value exceeds fifty pounds, but does not exceed one hundred pounds, an additional rate not exceeding six

shillings *per annum* for every single watercloset and for every single fixed bath :

And where the annual value exceeds one hundred pounds, an additional rate not exceeding eight shillings for every single watercloset and for every single fixed bath.

LXXVI. And with respect to high service the company may charge, in addition to the foregoing rates respectively, such further rates as they from time to time fix, not respectively exceeding twenty-five *per centum per annum* upon the foregoing several rates respectively.

LXXVII. That the company shall not be bound to supply more than one dwelling-house or other building by means of any one communication pipe.

LXXVIII. That the company may supply any person or body within their limits with water to be used within such limits for other than domestic purposes, at the rate and upon the terms and conditions agreed upon between the company and the person or body requiring such supply.

LXXIX. That the company may, at their own instance, and shall at the request of any owner or occupier of any premises situate in or adjoining any street in which any main or service pipe of the company is or shall be laid, and who requires a supply of water by measure for purposes other than the purposes in respect of which rates are by this Act provided or limited, and by means of communication pipes and other necessary and proper apparatus, to be provided, laid, and maintained at the cost of the person requiring such supply, afford a supply of water by meter or other fit and sufficient instrument or mode for measuring and ascertaining the quantity of water so supplied, and may charge for such supply not exceeding the following rates for every one thousand gallons (to wit),

In respect of ordinary service :

When the quarterly consumption of water does not exceed fifty thousand gallons, ninepence :

When exceeding fifty thousand gallons and not exceeding one hundred thousand gallons, eightpence :

When exceeding one hundred thousand gallons and not exceeding two hundred thousand gallons, sevenpence :

When exceeding two hundred thousand gallons, sixpence :

And in respect of high service :

An additional rate not exceeding twenty-five *per centum* upon those several rates for ordinary service :

Provided always that the company shall not be required so to supply water in any less quantity than twenty five thousand gallons in any quarter of a year.

LXXX. Provided always, that, notwithstanding any of the provisions of this Act, the company may take an increased rate or charge by agreement with any person or body requiring a supply of water, and notwithstanding the same exceed the rates or charges in this Act specified.

IV.—Southwark and Vauxhall Waterworks Company.

The following charges are authorised to be made by the Southwark and Vauxhall Waterworks Company (*vide* Southwark and Vauxhall Water Act, 1852):—

LIII. That the company shall, at the request of the owner or occupier of any house or part of a house occupied as a separate tenement in any street within their limits in which any main or service pipe of the company shall be laid, or of any other person who under this Act shall be entitled to demand a supply of water for domestic purposes, furnish to such person, by means of communication pipes and other necessary and proper apparatus, to be provided, laid down, and maintained at the cost of such person, a sufficient supply of water for his domestic purposes, at a rate *per centum per annum* on the aunual value of the house not exceeding five pounds:

If there be a water-closet or water-closets, or fixed bath or baths, or any high service in such dwelling-house or place, then, in addition to the rates above specified, the following rate shall be payable (that is to say),

Where the annual value of such house shall exceed thirty pounds but shall not exceed fifty pounds, a rate not exceeding four shillings *per annum* for each single water-closet, fixed bath, or high service, and a further sum of two shillings for each additional water-closet, fixed bath, or high service:

Where such annual value shall exceed fifty pounds but shall not exceed one hundred pounds, a rate not exceeding six shillings *per annum* for each single water-closet, fixed bath, or high service, and a further sum of three shillings for each additional water-closet, fixed bath, or high service:

Where such annual value shall exceed one hundred pounds but shall not exceed two hundred pounds, a rate not exceeding eight shillings for each single water-closet, fixed bath, or high service, and a further sum of four shillings for each additional water-closet, fixed bath, or high service:

Where such annual value shall exceed two hundred pounds but shall not exceed three hundred pounds, a rate not exceeding ten shillings for each single water-closet, fixed bath, or high service, and a further sum of five shillings for each additional water-closet, fixed bath, or high service:

And where such annual value shall exceed three hundred pounds, a rate not exceeding twelve shillings for each single water-closet, fixed bath, or high service, and a further sum of six shillings for each additional water-closet, fixed bath, or high service.

LIV. That the expression "high service" in this Act shall mean and be considered as being a delivery of water at an elevation more then ten feet above the footway or pavement in front of the dwelling house or other place supplied.

LV. That a supply of water for domestic purposes shall not include a supply of water for steam engines or railway purposes, or for warming or ventilating purposes, or for working any machine or apparatus, or for baths, horses, cattle, or for washing carriages, or for gardens, fountains, or ornamental purposes, or for flushing sewers or drains, or for any trade or manufacture or business requiring an extra supply of water.

LVI. That the company may supply any person or body within their limits with water to be used within such limits for other than domestic purposes, at such rate and upon such terms and conditions as shall be agreed upon between the company and the person or body requiring such supply.

LVII. That the company may at their own instance, and shall at the request of any owner or occupier of any premises situate in or adjoining any street in which any main or service pipe of the company shall be laid, and who requires a supply of water by measure for purposes other than the purposes in respect of which rates are by this Act provided or limited, and by means of communication pipes and other necessary and proper apparatus to be provided, laid, and maintained at the cost of the person requiring such supply, afford a supply of water by meter, or other

fit and sufficient instrument or mode for measuring and ascertaining the quantity of water so supplied, and may charge for such supply not exceeding the following rates for each one thousand gallons (that is to say),

In respect of ordinary service :

When the quarterly consumption of water does not exceed fifty thousand gallons, ninepence :

When exceeding fifty thousand gallons and not exceeding one hundred thousand gallons, eightpence :

When exceeding one hundred thousand gallons and not exceeding two hundred thousand gallons, sevenpence :

When exceeding two hundred thousand gallons sixpence :

And in respect of high service :

An additional rate not exceeding twenty-five *per centum* upon the several rates last hereinbefore specified and authorised for ordinary service :

Provided that the company shall not be required so to supply water in any less quantity than twenty-five thousand gallons in any quarter of a year.

V.—West Middlesex Waterworks Company.

The following charges are authorised to be made by the West Middlesex Waterworks Company (*vide* West Middlesex Waterworks Act, 1852) :—

XXXIX. That the company shall, at the request of the owner or occupier of any house in any street within the limits of this Act in which any pipe of the company shall be laid, or of any person who, under the provisions of this Act or any Act incorporated therewith, shall be entitled to demand a supply of water for domestic purposes, furnish to such owner or occupier or other person a sufficient supply of water for their domestic purposes at the rates hereinafter specified (that is to say),

Where the annual value of the dwelling house or other place supplied shall not exceed two hundred pounds, at a rate *per centum per annum* on such value not exceeding four pounds; and where such annual value shall exceed two hundred pounds, at a rate *per centum per annum* on such value not exceeding three pounds :

If there be a watercloset or waterclosets, or fixed bath or baths, or

any high service, in such dwelling house or place, then, in addition to the rates above specified, the following rates shall be payable (that is to say),

Where the annual value of such house shall exceed thirty pounds but shall not exceed fifty pounds, a rate not exceeding four shillings *per annum* for each single watercloset, fixed bath, or high service, and a further sum of two shillings for each additional watercloset, fixed bath, or high service:

Where such annual value shall exceed fifty pounds but shall not exceed one hundred pounds, a rate not exceeding six shillings *per annum* for each single watercloset, fixed bath, or high service, and a further sum of three shillings for each additional watercloset, fixed bath, or high service:

Where such annual value shall exceed one hundred pounds but shall not exceed two hundred pounds, a rate not exceeding eight shillings for each single watercloset, fixed bath, or high service, and a further sum of four shillings for each additional watercloset, fixed bath or high service:

Where such annual value shall exceed two hundred pounds but shall not exceed three hundred pounds, a rate not exceeding ten shillings for each single watercloset, fixed bath, or high service, and a further sum of five shillings for each additional watercloset, fixed bath, or high service:

And where such annual value shall exceed three hundred pounds, a rate not exceeding twelve shillings for each single watercloset, fixed bath, or high service, and a further sum of six shillings for each additional watercloset, fixed bath, or high service.

XL. That the expression "high service" in this Act shall mean and be considered as being a delivery of water at an elevation more than ten feet above the footway or pavement in front of the dwelling-house or other place so supplied.

XLI. Provided, that with respect to all service which shall be given to any dwelling-house at an elevation of more than two hundred feet above *Trinity* high-water mark, it shall be lawful for the company to charge, in addition to the rates hereinbefore authorised, a further sum not exceeding one pound *per centum per annum* on the annual value of such dwelling-house.

XLII. That a supply of water for domestic purposes shall not include a supply of water for steam engines or railway purposes, or for warming or ventilating purposes, or for working any machine or apparatus, or for baths, horses, cattle, or for washing carriages,

or for gardens, fountains, or ornamental purposes, or for flushing sewers or drains, or for any trade or manufacture or business requiring an extra supply of water.

XLIII. That the company may at their own instance, and shall at the request of any owner or occupier of any premises situate in or adjoining any street in which any main or service pipe of the company shall be laid, and who requires a supply of water by measure for purposes other than the purposes in respect of which rates are by this Act provided or limited, and by means of communication pipes and other necessary and proper apparatus to be provided, laid, and maintained at the cost of the person requiring such supply, afford a supply of water by meter, or other fit and sufficient instrument or mode for measuring and ascertaining the quantity of water so supplied, and may charge for such supply not exceeding the following rates for each one thousand gallons (that is to say),

In respect of ordinary service:

When the quarterly consumption of water does not exceed fifty thousand gallons, ninepence:

When exceeding fifty thousand gallons and not exceeding one hundred thousand gallons, eightpence:

When exceeding one hundred thousand gallons and not exceeding two hundred thousand gallons, sevenpence:

When exceeding two hundred thousand gallons, sixpence:

And in respect of high service:

An additional rate not exceeding twenty-five *per centum* upon the several rates last hereinbefore specified and authorised for ordinary service:

Provided that the company shall not be required so to supply water in any less quantity than twenty-five thousand gallons in any quarter of a year.

XLIV. That it shall be lawful for the company to supply any person or body within the limits of this Act with water, to be used within the limits aforesaid, for other than domestic purposes, at such rate and upon such terms and conditions as shall be agreed upon between the company and the person or body desirous of having such supply of water.

VI.—Grand Junction Waterworks Company.

The following charges are authorised to be made by the Grand Junction Waterworks Company (*vide* Grand Junction Waterworks Act, 1852):—

XLVI. That the company shall, at the request of the owner or occupier of any house in any street within the limits of this Act in which any pipe of the company shall be laid, or of any person who, under the provisions of this Act or any Act incorporated therewith, shall be entitled to demand a supply of water for domestic purposes, furnish to such owner or occupier or other person a sufficient supply of water for their domestic purposes at the rates hereinafter specified (that is to say),

Where the annual value of the dwelling-house or other place supplied shall not exceed two hundred pounds, at a rate *per centum* per annum on such value not exceeding four pounds; and where such annual value shall exceed two hundred pounds, at a rate *per centum per annum* on such value not exceeding, three pounds.

If there be a watercloset or waterclosets, or fixed bath or baths, or any high service in such dwelling-house or place, then, in addition to the rates above specified, the following rates shall be payable (that is to say),

Where the annual value of such house shall exceed thirty pounds but shall not exceed fifty pounds, a rate not exceeding four shillings per annum for each single watercloset, fixed bath, or high service, and a further sum of two shillings for each additional watercloset, fixed bath, or high service:

Where such annual value shall exceed fifty pounds but shall not exceed one hundred pounds, a rate not exceeding six shillings per annum for each single watercloset, fixed bath, or high service; and a further sum of three shillings for each additional watercloset, fixed bath, or high service:

Where such annual value shall exceed one hundred pounds but shall not exceed two hundred pounds, a rate not exceeding eight shillings for each single watercloset, fixed bath, or high service; and a further sum of four shillings for each additional watercloset, fixed bath, or high service:

Where such annual value shall exceed two hundred pounds but shall not exceed three hundred pounds, a rate not ex-

ceeding ten shillings for each single watercloset, fixed bath, or high service ; and a further sum of five shillings for each additional watercloset, fixed bath, or high service :

And where such annual value shall exceed three hundred pounds, a rate not exceeding twelve shillings for each single watercloset, fixed bath, or high service ; and a further sum of six shillings for each additional watercloset, fixed bath, or high service.

XLVII. That the expression "high service" in this Act shall mean and be considered as being a delivery of water at an elevation more than ten feet above the footway or pavement in front of the dwelling house or other place supplied.

XLVIII. That a supply of water for domestic purposes shall not include a supply of water for steam engines, or railway purposes, or for warming or ventilating purposes, or for working any machine or apparatus, or for baths, horses, cattle, or for washing carriages, or for gardens, fountains, or ornamental purposes, or for flushing sewers or drains, or for any trade or manufacture or business requiring an extra supply of water.

XLIX. That the company may supply any person or body within their limits with water to be used within such limits for other than domestic purposes, at such rate and upon such terms and conditions as shall be agreed upon between the company and the person or body requiring such supply.

L. That the company may, at their own instance, and shall, at the request of any owner or occupier of any premises situate in or adjoining any street in which any main or service pipe of the company shall be laid, and who requires a supply of water by measure, for purposes other than the purposes in respect of which rates are by this Act provided or limited, and by means of communication pipes and other necessary and proper apparatus to be provided, laid, and maintained at the cost of the person requiring such supply, afford a supply of water by meter or other fit and sufficient instrument or mode for measuring and ascertaining the quantity of water so supplied, and may charge for such supply not exceeding the following rates for each one thousand gallons (that is to say),

In respect of ordinary service :

When the quarterly consumption of water does not exceed fifty thousand gallons, ninepence :

When exceeding fifty thousand gallons, and not exceeding one hundred thousand gallons, eightpence :

When exceeding one hundred thousand gallons, and not exceeding two hundred thousand gallons, sevenpence:

When exceeding two hundred thousand gallons, sixpence:

And in respect of high service:

An additional rate not exceeding twenty-five *per centum* upon the several rates last hereinbefore specified and authorised for ordinary service:

Provided that the company shall not be required so to supply water in any less quantity than twenty-five thousand gallons in any quarter of a year.

VII.—Lambeth Waterworks Company.

The following charges are authorised to be made by the Lambeth Waterworks Company (*vide* Lambeth Waterworks Act, 1848):—

XXXVII. And be it enacted, that the company shall, at the request of the owner or occupier of any house or part of a house in any street within the limits of this Act in which any pipe of the company shall be laid, or of any person who, under the provisions of this Act or any Act incorporated therewith, shall be entitled to demand a supply of water for domestic purposes, furnish to such owner or occupier or other person a sufficient supply of water for their domestic uses at the rates hereinafter specified (that is to say),

If there be no water-closet in the dwelling-house or part of the dwelling house to be supplied with water, at the following rates:

Where the annual value of such house shall not exceed twenty pounds, at a rate *per centum per annum* not exceeding seven pounds ten shillings:

Where the annual value of such house shall exceed twenty pounds but shall not exceed forty pounds, at a rate per *centum per annum* not exceeding seven pounds:

Where such annual value shall exceed forty pounds, but shall not exceed sixty pounds, at a rate *per centum per annum* not exceeding six pounds ten shillings:

Where such annual value shall exceed sixty pounds but shall not exceed eighty pounds, at a rate *per centum per annum* not exceeding six pounds:

Where such annual value shall exceed eighty pounds but

shall not exceed one hundred pounds, at a rate *per centum per annum* not exceeding five pounds ten shillings:

And where such annual value shall exceed one hundred pounds, at a rate *per centum per annum* not exceeding five pounds:

If there be a water-closet or water-closets in such dwelling house, then, in addition to the rates above specified, the following rates shall be payable (that is to say),

Where the annual value of such dwelling-house shall exceed twenty pounds but shall not exceed forty pounds, a rate not exceeding ten shillings *per annum* for one water-closet, and a further sum of five shillings for each additional water-closet:

Where the annual value of such dwelling-house shall exceed forty pounds but shall not exceed sixty pounds, a rate not exceeding twelve shillings *per annum* for one water-closet, and a further sum of six shillings for each additional water-closet:

Where the annual value of such dwelling-house shall exceed sixty pounds but shall not exceed one hundred pounds, a rate not exceeding fifteen shillings for one water-closet, and a further sum of seven shillings and sixpence for each additional water-closet:

And where such annual value shall exceed one hundred pounds, at a rate not exceeding twenty shillings for one water-closet, and a further sum of ten shillings for each additional water-closet.

XXXVIII. And be it enacted, that it shall be lawful for the company to supply any person or body within the limits of this Act with water to be used within the limits aforesaid for other than domestic purposes at such rent and upon such terms and conditions as shall be agreed upon between the company and the person or body desirous of having such supply of water.

XXXIX. And be it enacted, that a supply of water for domestic purposes shall not include a supply of water for baths, horses, cattle, or for washing carriages, or for any trade or business whatsoever.

VIII.—Chelsea Waterworks Company.

The following charges are authorised to be made by the Chelsea Water Company (*vide* Chelsea Waterworks Act, 1852):—

LX. That the company shall, at the request of the owner or occupier of any house in any street within the limits of this Act in which any pipe of the company shall be laid, or of any person who, under the provisions of this Act or any Act incorporated therewith, shall be entitled to demand a supply of water for domestic purposes, furnish to such owner or occupier or other person a sufficient supply of water for their domestic purposes, at the rates hereinafter specified (that is to say),

Where the annual value of the dwelling-house or other place supplied shall not exceed two hundred pounds, at a rate *per centum per annum* on such value not exceeding four pounds:

And where such annual value shall exceed two hundred pounds, at a rate *per centum per annum* on such value not exceeding three pounds:

If there be a watercloset or waterclosets, or fixed bath or baths, or any high service, in such dwelling-house or place, then, in addition to the rates above specified, the following rates shall be payable (that is to say),

Where the annual value of such house shall exceed thirty pounds but shall not exceed fifty pounds, a rate not exceeding four shillings *per annum* for each single watercloset, fixed bath or high service, and a further sum of two shillings for each additional watercloset, fixed bath, or high service:

Where such annual value shall exceed fifty pounds but shall not exceed one hundred pounds, a rate not exceeding six shillings *per annum* for each single watercloset, fixed bath, or high service, and a further sum of three shillings for each additional watercloset, fixed bath, or high service:

Where such annual value shall exceed one hundred pounds but shall not exceed two hundred pounds, a rate not exceeding eight shillings for each single watercloset, fixed bath, or high service, and a further sum of four shillings for each additional watercloset, fixed bath, or high service:

Where such annual value shall exceed two hundred pounds

but shall not exceed three hundred pounds, a rate not exceeding ten shillings for each single watercloset, fixed bath, or high service, and a further sum of five shillings for each additional watercloset, fixed bath, or high service :

And where such annual value shall exceed three hundred pounds, a rate not exceeding twelve shillings for each single watercloset, fixed bath, or high service, and a further sum of six shillings for each additional watercloset, fixed bath, or high service.

LXI. That the expression "high service" in this Act shall mean and be considered as being a delivery of water at an elevation more than ten feet above the pavement in front of the dwelling-house or other place supplied.

LXII. That with respect to the several rates above specified a supply of water for domestic purposes shall not include a supply of water for steam engines or railway puposes, or for warming or ventilating purposes, or for working any machine or apparatus, or for public baths, horses, cattle, or for washing carriages, or for gardens, fountains, or ornamental purposes, or for flushing sewers or drains, or for any trade or manufacture or business requiring an extra supply of water.

LXIII. That it shall be lawful for the company to supply any person or body within the limits of this Act with water, to be used within the limits aforesaid for other than domestic purposes, at such rate and upon such terms and conditions as shall be agreed upon between the company and the person or body desirous of having such supply of water.

STATUTORY POWERS AS TO DIVIDENDS.

The following is a copy of a paper which was submitted to the Select Committee appointed to report on the London Water Supply, 1880.

With respect to the powers of the Water Companies as to dividends, the following questions arise :

1. What is the maximum rate of dividend authorised?
2. What is the right of the shareholders to back dividends?

The answers to these questions depend upon the general and special legislation applicable to each case.

I. GENERAL LEGISLATION.

The general legislation on the subject is chiefly contained in the following provisions :—

Section 75 of the Waterworks Clauses Act, 1847, enacts that "The profits of the undertaking to be divided amongst the undertakers in any year, shall not exceed the prescribed rate, or where no rate is prescribed, they shall not exceed the rate of ten pounds in the hundred by the year, on the paid-up capital in the undertaking, which in such case shall be deemed the prescribed rate, unless a larger dividend be at any time necessary to make up the deficiency of any previous dividend which shall have fallen short of the said yearly rate."

Sections 76–78 provide for the formation, out of surplus profits, of a reserved fund; and by Section 79 it is enacted that "If in any year the profits of the undertaking divisible amongst the undertakers shall not amount to the prescribed rate, such a sum may be taken *from the Reserved Fund* as, with the actual divisible profits of such year, will enable the undertakers to make a dividend of the amount aforesaid, and so from time to time as often as the occasion shall require."

Section 121 of the Companies Clauses Act, 1845, prohibits the making of dividends, so as to reduce capital. The provision is incorporated in the special Acts of most of the Water Companies, but need not be further noticed for the purposes of this memorandum.

By Sections 80–83 of the Waterworks Clauses Act, 1847, provisions are made for obliging the undertakers, when they have paid their maximum dividends, and have a reserve fund intact, to reduce the price of water. "Prescribed" in the above enactments means "prescribed for that purpose in the special Act."

It is open to question whether the Waterworks Clauses Act, 1847, can, in the absence of special provision, be effectually incorporated with a special Act of a water company which does not authorise any new works; inasmuch as Section 1 of the Waterworks Clauses Act, 1847, enacts "That this Act shall extend only to such Waterworks as shall be authorised by any Act of Parliament hereafter to be passed, which shall declare that this Act shall be incorporated therewith. And all the clauses of this Act, save so far as they shall be expressly varied or excepted by any such Act, shall apply to the undertaking authorised thereby, so far as the same shall be applicable to such undertaking, and shall, with the clauses of every other Act which shall be incorporated therewith, form part of such Act, and be construed therewith as forming one Act."

II. SPECIAL LEGISLATION.*

The following are the chief provisions in the Special Legislation affecting the several companies in relation to the points referred to.

No. 1.—The Kent Company.

The special Act of 1862 (which is the chief Act) fixed the share capital at £420,000, all of which was to be ordinary, and it repealed the provisions of the previous special Acts with respect to the raising of capital. It did not incorporate the Waterworks Clauses Act, or make any regulations as to dividends.

* *Note.*—In the original paper the companies followed each other in a different order. They have been transposed here so as to preserve the numerical arrangement adopted throughout this book, but without alteration of matter.

The special Act of 1864, which amalgamated the Kent and the North Kent Companies, incorporated the Waterworks Clauses Act, unless where expressly varied or excepted by the special Act (Section 2), and whilst giving power to raise fresh share capital to the extent of £180,000, made no express provision as to dividends. It did not extend the application of those Acts.

The special Act of 1877 incorporated in itself the previous Acts, and also the provisions of the Companies Clauses Act, 1845, "with respect to the making of dividends." It gave powers to create new shares or stock amounting to £160,000, to "form part of the capital," and to be entitled to a dividend with shares or stock of the same class or description; but by Section 26 the new shares, if ordinary, were only to bear 7 per cent., and, if preference, only 6 per cent. It is also provided by Section 27 that: "In case in any half year the net revenues of the company applicable to dividend shall be insufficient to pay the full amount of the maximum rate to which each class of ordinary stock or shares in the capital of the company is entitled, a rateable deduction shall be made in the dividend of each class."

No. 2.—The New River Company.

The special Act of 1852, which is now the chief Act, fixed the Company's capital at £1,519,958, with power to raise further sums, amounting to £400,000, by bond. This Act by Section 3 incorporates the Waterworks Clauses Act, with certain exceptions not affecting profits or dividends, but it provides "that the clauses with respect to the construction of works for the accommodation of lands adjoining the water-works, and with respect to mines, shall not apply to any works constructed on lands acquired by the Company previously to the passing of the Act." The Act authorised the construction of certain new works. No rate of dividend is expressly prescribed by it, or by the previous special Acts.

The special Acts of 1854 authorised the construction of certain works, and the raising of money by bond. Certain sections of the Waterworks Clauses Act, but not those relating to dividends, are incorporated, and it is declared that they shall extend only to the several works by these Acts authorised to be made.

By Section 5 of the special Act of 1857 the Company were empowered to convert their bond debt into a permanent debenture stock, bearing a fixed dividend not exceeding 5 per cent. The

Act contains no other provision as to dividend, and does not incorporate the sections of the Waterworks Clauses Act as to dividends.

The special Act of 1866, by Sections 3 and 4, empowered the company to issue new shares of the nominal value of £100 each, to the amount of £500,000; and by Section 10 the proprietors of such shares were to be entitled to dividend *pari passu* with the proprietors of original shares. The Act does not incorporate the Waterworks Clauses Act.

The special Act of 1879 further authorised the issue of debenture stock to the amount of £500,000 (to be known as "Debenture Stock B," that of 1857 being "Debenture Stock A"), to bear a fixed dividend not exceeding 4 per cent. This Act does not incorporate the Waterworks Clauses Act.

No. 3.—The East London Company.

The special Acts of 1807 and 1808 do not appear to contain any provision as to dividend, except that they provide that it shall be in proportion to the amount subscribed by each proprietor. The special Act of 1853 (which is the chief Act) incorporates the Waterworks Clauses Act, 1847, and it provides that "for the purposes of this Act the expression 'the undertaking' in the Waterworks Clauses Act, 1847, means the water-works and works connected therewith by this Act, authorised to be constructed *and maintained* respectively." (*See* also Sect. 7.) It fixes the capital at £675,000 of general stock, which might be afterwards extended £975,000. In the case of new shares having a guaranteed or preferential dividend, the rate of dividend is not to exceed 5 per cent. (Sect. 22.)

There were two special Acts in 1867. By the first, additional, works and capital (£260,000) were authorised. The Act however, does not incorporate the provisions of the Waterworks Clauses Act, 1847, with respect to dividends, and it does not contain any express provisions relating thereto. The second Act also authorises additional works and capital (£160,000). It incorporates the Waterworks Clauses Act, 1847, as regards dividends.

No. 4.—The Southwark and Vauxhall Company.

The special Act of 1852 repealed the previous Acts but continued the company, and incorporated the Waterworks

Clauses Act, 1847, except certain provisions not relating to dividends, and enacted that it should be held to apply to the company, and to the undertaking and works thereby authorised, and also, except as regards mines, notwithstanding any words of restriction contained in the Act, to the water-works, credits, and effects thereby vested in the company; and that the expression, "the undertaking," used in the Waterworks Clauses Act, 1847, shall mean not only the works authorised by the Act of 1852, but also the works by that Act vested in the company. The then authorised share capital was £400,000. The Act further authorised the issue of new shares to the amount of £180,000, provided that the amount of dividend to be guaranteed to any such shares should not exceed 7 per cent.

The special Act of 1855 (Section 11) declares that the share capital of the company shall be £900,000, and prescribes, with reference to the Waterworks Clauses Act, 1847, a dividend of 10 per cent. on £700,000, and of 7½ per cent. on the residue of the capital. Section 19 declares that the share capital created under the Act shall be part of the general capital of the company, and subject to its privileges, liabilities, and incidents.

The special Act of 1864 authorised a further issue of new shares to the amount of £300,000, to be part of the general capital of the company (Sections 4 and 5). The shareholders to be entitled to take proportionate privileges, and the shares to be subject to the like restrictions and incidents as if they were part of the original capital.

The special Act of 1867 authorised the issue of new shares to the like amount of £300,000, to be part of the general capital of the company, as in the preceding Act.

The special Act of 1872 authorised the issue of new shares to the amount of £400,000, to form part of the general capital in the same way as in the two preceding Acts.

No. 5.—The West Middlesex Company.

The special Act of 1806, which incorporated the company, states that the subscribers "shall be entitled to and receive the entire and net distribution of an equal proportionate part" of the profits, according to their contributions; and the special Act of 1810 applied this provision to the holders of shares issued under its authority. A similar provision occurs in the special Act of 1813.

The special Act of 1852, which is the chief Act, incorporates by Section 3 the Waterworks Clauses Act, 1847, without expressly extending its application, and fixes the capital at £506,300, divided into 8300 shares of £61 each (Section 6). It does not contain any express provision as to dividends.

The special Act of 1860 authorises the company to raise further capital to the extent of £180,000, either on mortgage or by the issue of new shares, preferential or otherwise, provided that if in any year the profits were not sufficient for the full amount of the preferential dividend for that year, the deficiency should not be made good out of the profits of a subsequent year, or out of any other funds. The new capital was to be part of the general capital.

The special Act of 1866 incorporates the Waterworks Clauses Act of 1847, but has no reference to capital.

The special Act of 1869 does not incorporate the Waterworks Clauses Act; it authorises the issue of new shares, which may be either ordinary or preferential, to the amount of £300,000, which is to form part of the general capital of the company. Section 7 empowers the company to issue debenture stock, to which the company may attach "such fixed and perpetual dividend as they think fit."

No. 6.—The Grand Junction Company.

The first special Act after 1847 is that of 1852. It incorporates the Waterworks Clauses Act, 1847, without extending its application. The Act, however, authorises fresh works. The Act authorises £100,000 additional share capital, the existing share capital being £331,000.

The special Act of 1855 does not incorporate the Waterworks Clauses Act, but by Section 6 enacts that (with reference to the Waterworks Clauses Act, 1847, with respect to the amount of profits to be received by the undertakers when the waterworks are carried on for their benefit) "The prescribed rate of profit shall be as follows (that is to say), as regards the sum of £546,000 (the amount which, immediately before the passing of this Act, the company were authorised to raise), £10 in the £100 by the year, and as regards the residue of their capital, £7 10*s.* in the £100 by the year." Under Section 5 the total share capital was to be £700,000.

The special Act of 1868 authorises the creation of new shares

to the amount of £300,000 to be part of the "general capital." The shares might be ordinary or preferential, and the shareholders were to be entitled to the like proportionate privileges, and be subject to the like restrictions and incidents as if the shares were part of the original capital. It does not incorporate the Waterworks Clauses Act.

The special Act of 1878 incorporates the Waterworks Clauses Acts, and authorises the creation of new shares or stock to the amount of £300,000, to be on the same footing as the "existing capital;" but by Section 16 so much of it as was ordinary capital was only to bear 7 per cent., whilst the preference shares were limited to 6 per cent.

Section 17 provides, that if in any year the net revenue of the company applicable to dividends is insufficient to pay the full amount of the prescribed rate of dividend on each class of ordinary stock or shares, the revenue shall be applied, in the first place, in payment of dividend on all the ordinary paid-up capital up to 7 per cent., and next of a further dividend up to 10*s*. per cent. on the ordinary paid-up capital, created under previous Acts, and the balance in payment of dividend upon ordinary paid-up capital entitled to a higher rate than 7½ per cent.

No. 7.—The Lambeth Company.

The principal special Act (that of 1848) repeals the former Acts, and incorporates the Waterworks Clauses Act, 1847, except where the same shall be inconsistent with, or repugnant to, any of the provisions of the Act, "and it is to be held to apply to the company thereby incorporated, and to the water-works, lands, credits and effects, authorised to be made by and vested in the company." It provides for the creation of £200,000 new share capital, and there was an existing capital of £143,800. There is no special provision in the Act as to the rate of dividend.

The special Act of 1856 authorises further share capital of £406,200. It incorporates the sections of the Waterworks Clauses Act, 1847, with respect to dividends, but it provides that the prescribed rate of dividend on the new capital shall not exceed 7½ per cent.

The special Act of 1869, by Section 6, authorises new share capital of £500,000, either preference or ordinary, and Section 8 directs that the new capital shall be part of the general capital of the company. Section 17 enacts that "The Directors, without the

direction or sanction of a general meeting, from time to time may declare and pay, in the interval between any two ordinary annual meetings, a half year's dividend, payable out of the profits of the company, to the shareholders; but the directors shall not make any dividend whereby the capital would be reduced." This Act does not incorporate the Waterworks Clauses Act, 1847, nor expressly prescribe a rate of dividend.

The special Act of 1871, which authorises new works, incorporates the Waterworks Clauses Act, so far as applicable to the purposes, and not inconsistent with the provisions of the special Act. It is not, however, an Act having any direct bearing on capital or profits.

No. 8.—The Chelsea Company.

The Chelsea Waterworks Act of 1852, which is the principal of the company's special Acts, and which regulates the organisation of the company as regards its capital and stock, by Section 13 incorporates the Waterworks Clauses Act, 1847, except certain specified provisions which have no reference to dividends. The existing capital was £300,000, and the Act authorises a further sum of £270,000.

The same section also provides that "the expression 'the undertaking,' used in the Waterworks Clauses Act, 1847, shall mean not only the water-works and the works connected therewith by this Act authorised to be constructed, but also the water-works and other works by this Act vested in the company," being the existing works (*see* sec. 5).

The Chelsea Waterworks Act of 1864, which confers fresh powers of raising capital (£285,000), does not expressly incorporate the Waterworks Clauses Act, 1847, or expressly except it.

The Chelsea Waterworks Act of 1875, which is also an Act authorising the raising of new capital—viz., £160,000 in addition to the ordinary share capital—by Section 2 incorporates the provisions of the Waterworks Clauses Act, 1847, with respect to the amount of profit to be received by the undertakers.

The following express provision with regard to dividends is contained in Section 24 of the Act of 1852:—"The proprietor of any share in the company shall not be entitled to any further or greater dividends than in respect of the sums which are under this Act to be deemed to have been, or which may for the time being have been paid up on such shares."

The Chelsea Acts contain no express provisions prescribing the amount of dividend; but, as already stated, the Acts of 1852 and 1875 incorporate the sections relating to dividends of the Waterworks Clauses Act, 1847.

The Act of 1864, which authorised fresh capital, does not incorporate those sections, but it does not except them; and Section 13 directs that the money raised under the Act shall be applied to any of the purposes of the undertaking.

REGULATIONS UNDER THE "METROPOLIS WATER ACT, 1871."

At the Council Chamber, Whitehall,

The 10th day of August, 1872.

Present:—The Right Hon. Chichester P. Fortescue, M.P.

WHEREAS it is provided by the Metropolis Water Act, 1871 [section 17], that every Company subject to the provisions of that Act shall, within six months after the passing of the said Act, make Regulations for the purposes for which Regulations may be made under the authority of section 26 of the Metropolis Water Act, 1852, and that the provisions of that section shall apply also to the preventing of undue consumption or contamination of water:

And whereas by the said Metropolis Water Act, 1871 [section 22], it is further provided that no such Regulation shall be of any force or effect unless and until the same be submitted to and confirmed by the Board of Trade, who may institute such inquiry in relation thereto as they shall think fit, and who, at such inquiry, shall hear the Metropolitan Authority and the Company, if desiring to be heard, and the said Board shall, if they think fit, or if requested, nominate and have present at such inquiry, to advise and assist them, a competent and impartial waterworks engineer:

And whereas it is by the said last-mentioned Act also provided, that no such Regulation shall be confirmed by the Board of Trade, unless notice in that behalf shall have been given by the Company to which the same relates, or by such person as the Board of Trade direct, in the London Gazette, and in two daily morning newspapers circulated within the limits of the said Act, one month at least before the inquiry, and that one month at least before any such inquiry is held, a copy of the Regulations in

question shall be sent by such Company, or person, to the office of the Metropolitan Authority, and the same shall for one month be kept open during office hours at the respective offices of the Metropolitan Authority and of the said Company, to the inspection of all persons without fee or reward :

And whereas the Metropolitan Water Companies and the Tottenham Local Board made regulations, in accordance with the provisions of the above-named Act, and submitted the same to the Board of Trade for confirmation, and duly advertised and deposited the same with the Metropolitan Authorities :

And whereas the Metropolitan Board of Works and the Corporation of the City of London, being Metropolitan Authorities under the said last-mentioned Act, submitted objections to the said regulations, and it was deemed expedient that an inquiry should be held in relation thereto :

And whereas by the Board of Trade Inquiries Act, 1872, it is provided that wherever in any Act of Parliament it is directed that an inquiry shall be held or instituted by the Board of Trade, the same shall be deemed to have been duly held or instituted, if conducted by any person or persons duly authorised in that behalf by the President of the said Board, by writing under his hand or under the hand of one of the secretaries of the said Board :

And whereas the Board of Trade, under the powers conferred upon them as aforesaid, appointed the Right Honourable Lord Methuen, Henry Whatley Tyler, Esquire, late Captain Royal Engineers, and Robert Rawlinson, Esquire, C.E., C.B., to hold an inquiry in relation to the regulations so submitted to them by the Companies, and by the Tottenham Local Board :

And whereas the said inquiry has been held, and the said Metropolitan Authorities and the Companies and the Local Board have been heard at the inquiry :

And whereas, as the result of such inquiry, it has appeared expedient to the Board of Trade to allow such and so many of the said Regulations as are contained in the Schedule hereto annexed, with such modifications and alterations as are shown in the said Schedule :

NOW, THEREFORE, the Board of Trade do hereby confirm the said last-named Regulations so modified and altered as aforesaid.

(Signed) C. P. FORTESCUE.

[SCHEDULE.

SCHEDULE REFERRED TO IN THE ABOVE MINUTE

REGULATIONS MADE UNDER THE "METROPOLIS WATER ACT, 1871."

1. *Place of communication-pipe.*—No "communication-pipe" for the conveyance of water from the waterworks of the Company into any premises shall hereafter be laid until after the point or place at which such "communication-pipe" is proposed to be brought into such premises shall have had the approval of the Company.

2. *Weight of lead-pipes.*—No lead-pipe shall hereafter be laid or fixed in or about any premises for the conveyance of or in connection with the water supplied by the Company (except when and as otherwise authorised by these regulations, or by the Company), unless the same shall be of equal thickness throughout, and of at least the weight following, that is to say :—

Internal Diameter of Pipe in Inches.	Weight of Pipe in lbs. per Lineal Yard.
$\frac{3}{8}$-inch diameter.	5 lbs. per lineal yard.
$\frac{1}{2}$ " "	6 " "
$\frac{5}{8}$ " "	$7\frac{1}{2}$ " "
$\frac{3}{4}$ " "	9 " "
1 " "	12 " "
$1\frac{1}{4}$ " "	16 " "

3. *Interior pipes.*—Every pipe hereafter laid or fixed in the interior of any dwelling-house for the conveyance of, or in connection with, the water of the Company, must, unless with the consent of the Company, if in contact with the ground, be of lead, but may otherwise be of lead, copper, or wrought iron, at the option of the consumer.

4. *Not more than one communication-pipe to each house.*—No house shall, unless with the permission of the Company in writing, be hereafter fitted with more than one "communication-pipe."

5. *Every house, with certain exceptions, to have its own communication-pipe.*—Every house supplied with water by the Company (except in cases of stand pipes) shall have its own separate

"communication-pipe." Provided that, as far as is consistent with the special Acts of the Company, in the case of a group or block of houses, the water-rates of which are paid by one owner, the said owner may, at his option, have one sufficient "communication-pipe" for such group or block.

6. *No house to have connection with fittings of adjoining house.*—No house supplied with water by the Company shall have any connection with the pipes or other fittings of any other premises, except in the case of groups or blocks of houses, referred to in the preceding Regulation.

7. *Connection to be by ferrule or stop-cock.*—The connection of every "communication-pipe" with any pipe of the Company shall hereafter be made by means of a sound and suitable brass screwed ferrule or stop-cock with union, and such ferrule or stop-cock shall be so made as to have a clear area of waterway equal to that of a half-inch pipe. The connection of every "communication-pipe" with the pipes of the Company shall be made by the Company's workmen, and the Company shall be paid in advance the reasonable costs and charges of and incident to the making of such connection.

8. *Material and joints of external pipes.*—Every "communication-pipe" and every pipe external to the house and through the external walls thereof, hereafter respectively laid or fixed, in connection with the water of the Company shall be of lead, and every joint thereof shall be of the kind called a "plumbing" or "wiped" joint.

9. *No pipe to be laid through drains, &c.*—No pipe shall be used for the conveyance of, or in connection with, water supplied by the Company, which is laid or fixed through, in, or into any drain, ashpit, sink, or manure-hole, or through, in, or into any place where the water conveyed through such pipe may be liable to become fouled, except where such drain, ashpit, sink, or manure-hole, or other such place, shall be in the unavoidable course of such pipe, and then in every such case such pipe shall be passed through an exterior cast-iron pipe or jacket of sufficient length and strength, and of such construction as to afford due protection to the water-pipe.

10. *Depth of pipes under ground.*—Every pipe hereafter laid for the conveyance of, or in connection with, water supplied by the Company, shall, when laid in open ground, be laid at least two feet six inches below the surface, and shall in every exposed situation be properly protected against the effects of frost.

11. *No connection with rain-water receptacle.*—No pipe for the conveyance of, or in connection with, water supplied by the Company, shall communicate with any cistern, butt, or other receptacle used or intended to be used for rain-water.

12. *Stop-volve.*—Every "communication-pipe" for the conveyance of water to be supplied by the Company into any premises shall have at or near its point of entrance into such premises, and if desired by the consumer within such premises, a sound and suitable stop-valve of the screw-down kind, with an area of waterway not less than that of a half-inch pipe, and not greater than that of the "communication-pipe," the size of the valve within these limits being at the option of the consumer. If placed in the ground such "stop-valve" shall be protected by a proper cover and "guard-box."

13. *Character of cisterns and ball-taps.*—Every cistern used in connection with the water supplied by the Company shall be made and at all times maintained water-tight, and be properly covered and placed in such a position that it may be inspected and cleansed. Every such existing cistern, if not already provided with an efficient "ball-tap," and every such future cistern shall be provided with a sound and suitable "ball-tap" of the valve kind for the inlet of water.

14. *Waste pipes to be removed or converted into warning-pipes.*—No overflow or waste-pipe other than a "warning-pipe" shall be attached to any cistern supplied with water by the Company, and every such overflow or waste-pipe existing at the time when these regulations come into operation shall be removed, or at the option of the consumer shall he converted into an efficient "warning-pipe," within two calendar months next after the Company shall have given to the occupier of, or left at the premises in which such cistern is situate, a notice in writing requiring such alteration to be made.

15. *Arrangement of warning-pipes.* — Every "warning-pipe" shall be placed in such a situation as will admit of the discharge of the water from such "warning-pipe" being readily ascertained by the officers of the Company. And the position of such "warning-pipe" shall not be changed without previous notice to and approval by the Company.

16. *Buried cisterns prohibited.*—No cistern buried or excavated in the ground shall be used for the storage or reception of water supplied by the Company, unless the use of such cistern shall be allowed in writing by the Company.

17. *Butts prohibited.*—No wooden receptacle without a proper metallic lining shall be hereafter brought into use for the storage of any water supplied by the Company.

18. *Ordinary draw-tap.*—No draw-tap shall in future be fixed unless the same shall be sound and suitable and of the "screw-down" kind.

19. *Draw-taps in connection with stand-pipes.*—Every draw-tap in connection with any "stand-pipe" or other apparatus outside any dwelling-house in a court or other public place, to supply any group or number of such dwelling-houses, shall be sound and suitable and of the "waste-preventer" kind, and be protected as far as possible from injury by frost, theft, or mischief.

20. *Boilers, water-closets, and urinals to have cisterns.*—Every boiler, urinal, and water-closet, in which water supplied by the Company is used (other than water-closets in which hand flushing is employed), shall, within three months after these regulations come into operation, be served only through a cistern or service-box and without a stool-cock, and there shall be no direct communication from the pipes of the Company to any boiler, urinal, or water-closet.

21. *Water-closet apparatus.*—Every water-closet cistern or water-closet service-box hereafter fitted or fixed in which water supplied by the Company is to be used shall have an efficient waste-preventing apparatus, so constructed as not to be capable of discharging more than two gallons of water at each flush.

22. *Urinal-cistern apparatus.*—Every urinal-cistern in which water supplied by the Company is used other than public urinal-cisterns, or cisterns having attached to them a self-closing apparatus, shall have an efficient "waste-preventing" apparatus, so constructed as not to be capable of discharging more than one gallon of water at each flush.

23. *Water-closet down-pipes.*—Every "down-pipe" hereafter fixed for the discharge of water into the pan or basin of any water-closet shall have an internal diameter of not less than one inch and a quarter, and if of lead shall weigh not less than nine pounds to every lineal yard.

24. *Pipes supplying water-closet to communicate with cistern only.*—No pipe by which water is supplied by the Company to any water-closet shall communicate with any part of such water-closet, or with any apparatus connected therewith, except the service-cistern thereof.

25. *Bath to be without overflow pipe.*—No bath supplied with

water by the Company shall have any overflow waste-pipe, except it be so arranged as to act as a "warning-pipe."

26. *Bath apparatus.*—In every bath hereafter fitted or fixed the outlet shall be distinct from, and unconnected with, the inlet or inlets; and the inlet or inlets must be placed so that the orifice or orifices shall be above the highest water level of the bath. The outlet of every such bath shall be provided with a perfectly water-tight plug, valve, or cock.

27. *Alteration of fittings.*—No alteration shall be made in any fittings in connection with the supply of water by the Company without two days' previous notice in writing to the Company.

28. *Waterway of fittings.*—Except with the written consent of the consumer, no cock, ferrule, joint, union, valve, or other fitting, in the course of any "communication-pipe," shall have a waterway of less area than that of the "communication-pipe," so that the waterway from the water in the district-pipe or other supply-pipe of the Company up to and through the stop-valve prescribed by Regulation No. 12, shall not in any part be of less area than that of the "communication-pipe" itself, which pipe shall not be of less than a half-inch bore in all its course.

29. *Weight of lead pipes having open ends.*—All lead "warning-pipes" and other lead pipes of which the ends are open, so that such pipes cannot remain charged with water, may be of the following minimum weights, that is to say—

½-inch (internal diameter)	. . . .	3 lbs. per yard.
¾ " "	. . . .	5 "
1 " "	. . . .	7 "

30. *Definition of "communication-pipe."*—In these Regulations the term "communication-pipe" shall mean the pipe which extends from the district pipe or other supply pipe of the Company up to the "stop-valve" prescribed in the Regulation No. 12.

31. *Penalties.*—Every person who shall wilfully violate, refuse, or neglect to comply with, or shall wilfully do or cause to be done any act, matter, or thing, in contravention of these Regulations, or any part thereof, shall, for every such offence, be liable to a penalty in a sum not exceeding 5*l.*

32. *Authorised officer may act for company.*—Where under the foregoing Regulations any act is required or authorised to be done by the Company, the same may be done on behalf of the Company by an authorised officer or servant of the Company,

and where under such Regulations any notice is required to be given by the Company the same shall be sufficiently authenticated if it be signed by an authorised officer or servant of the Company.

33. *Existing fittings.*—All existing fittings, which shall be sound and efficient, and are not required to be removed or altered under these Regulations, shall be deemed to be prescribed fittings under the "Metropolis Water Act, 1871."

APPENDIX II.

THE INTERNATIONAL HEALTH EXHIBITION OF 1884.

DESCRIPTION OF THE WATER PAVILION.

In the month of January, 1884, H.R.H. the Prince of Wales addressed a letter to each of the eight Metropolitan Water Companies stating that, considering the great importance of the Water Supply of the Metropolis, it had been suggested that the several Companies supplying London with water should be invited to make a collective exhibit at the forthcoming International Health Exhibition, and requesting their co-operation—such exhibit to embrace all that related to the Sources of Supply, Collection, Filtration and Distribution, as well as to House Storage and fittings, Constant Supply, Economy and Waste of Water, and its use for every domestic purpose. In reply to this communication the Companies at once returned promises of their cordial support to the proposal, and a Sub-Committee was formed to carry out the designs and general arrangement of the exhibit. Colonel Sir Francis Bolton, C.E., the Water Examiner to the Metropolis, was appointed at the head of this Sub-Committee, which also comprised the Engineers of the Companies (whose names are given below under the separate description of the exhibits of each Company), and in addition the following gentlemen:—Professor F. de Chaumont, M.D., F.R.S.; Brigade-Surgeon W. G. Don, A.M.D.; Professor E. Frankland, D.C.L., F.R.S.; S. H. Louttit, Esq., C.E.; W. H. Michael, Esq., Q.C.; Philip A. Scratchley, Esq., M.A.; Arthur Telford Simpson, Esq., M. Inst. C.E.; Thomas Stevenson, Esq., M.D.; John Taylor, Esq., M. Inst. C.E.; Colonel C. E. Webber, R.E., C.B.

A Pavilion was specially constructed for the purpose of this Collective Exhibit, the object of which is to show the manner in which the inhabitants of London are supplied with water, and to convey to the general public as clear an idea as may be of the magnitude and importance of the Metropolitan Water Supply.

The Pavilion is an octagonal building, that shape having been adopted in order that each Company might have one side of the octagon for its exhibits.

From the interior angles of the Pavilion spring eight willow trees, the branches of which, being brought to an apex, form a kind of dome. The ground-work of the dome is covered by "Lincrusta Walton" decoration, in imitation of carved and fluted cedar, supplied by Messrs. F. Walton & Co., who claim for their Lincrusta that it has many valuable sanitary qualities, is impermeable to moisture, and thoroughly waterproof. The floor is laid with Rust's vitreous mosaic, by Messrs. S. Belham & Co., and is of a blue colour, to be in character with the rivers Thames and Lee.

The walls are hung with paintings by Mr. J. H. Hooper, showing the intakes and portions of the works of the several Companies. Isometrical plans, maps of the districts supplied, descriptions of the works, and statistical tables (specially compiled for the purposes of this Exhibition), giving, amongst other things, particulars as to quantity, and the area under constant supply, are also shown.

The walls of the Pavilion are decorated by a frieze, the work of Mrs. Wallroth, of Sunbury, painted on a silver ground, representing river-birds and plants.

In the centre of the Pavilion is a handsome fountain, lent by the Coalbrookdale Company, representing a swan and boy resting on a basin supported by water-lilies and other aqueous plants.

At each of the interior angles of the octagon are filter-beds, supported on a base of Norwegian marble (supplied by the Northern Stone and Marble Company), which illustrate the system of filtration adopted by each Com-

pany. This marble is said to be easily and cheaply worked and takes an excellent polish. In front of the filter-beds are glass tubes, mounted in nickel silver, conveying running water to the drinking fountains of each particular Company. During the continuance of the Exhibition the official analyses of the water which each Company supplies are attached to these fountains.

The filters, and the glass flowers used in the decorations of the Water Pavilion, have been furnished by Messrs. Defries & Sons. The patent washable mouldings were supplied by Messrs. Schulze & Co., the manufacturers. The general decorations of the Pavilion were carried out by Mr. Labhart. Messrs. William Woollams & Co. supplied the varnished papers for the walls of the outer corridor. The three cocoa-nut fibre mats laid down at the three entrances were lent by Messrs. Treloar & Sons. The patent india-rubber guards fixed on the stairs to prevent slipping were supplied by Messrs. A. Hutchinson & Co.

In the outer annexe, or corridor of the Pavilion, are the special exhibits of each Company, and at regular intervals there are specimens of the different large mains used in the Metropolis, varying in size from thirteen to forty-eight inches, as well as water meters and hydrants. The number of miles of mains used is painted on each specimen.

Several most interesting specimens of the old stone, wooden, and concrete pipes used in bygone days are exhibited side by side with the iron mains of modern times.

In the outer corridor, also, on the left of the main entrance to the Pavilion, is an exhibit which is unique in its way, being a case lent by the Aqueous Works and Diamond Rock-Boring Company, containing a remarkable and extensive collection of "cores" of different strata obtained in artesian and other borings by means of the diamond-drill, some of which have been brought up from considerable depths. Several artesian wells have been executed for different Water Companies by this system.

In the retiring angle south of the door is a specimen of a flexible pipe as used by the Southwark and Vauxhall

Company, and in the retiring angle to the north is a complete section shewing a large main as laid in a London street, with all the necessary cocks and appliances. There is also a complete section of a house supplied with fittings in accordance with the requirements of the Metropolis Water Act of 1871.

Mr. G. G. Adams, of Sloane Street, has lent for exhibition in the Water Pavilion a cast of his well-known statue, "The Diver."

Messrs. Merryweather & Sons have lent hose pipes, branches, firemen's equipment, &c., as used by the Water Companies, which are also exhibited in the annexe.

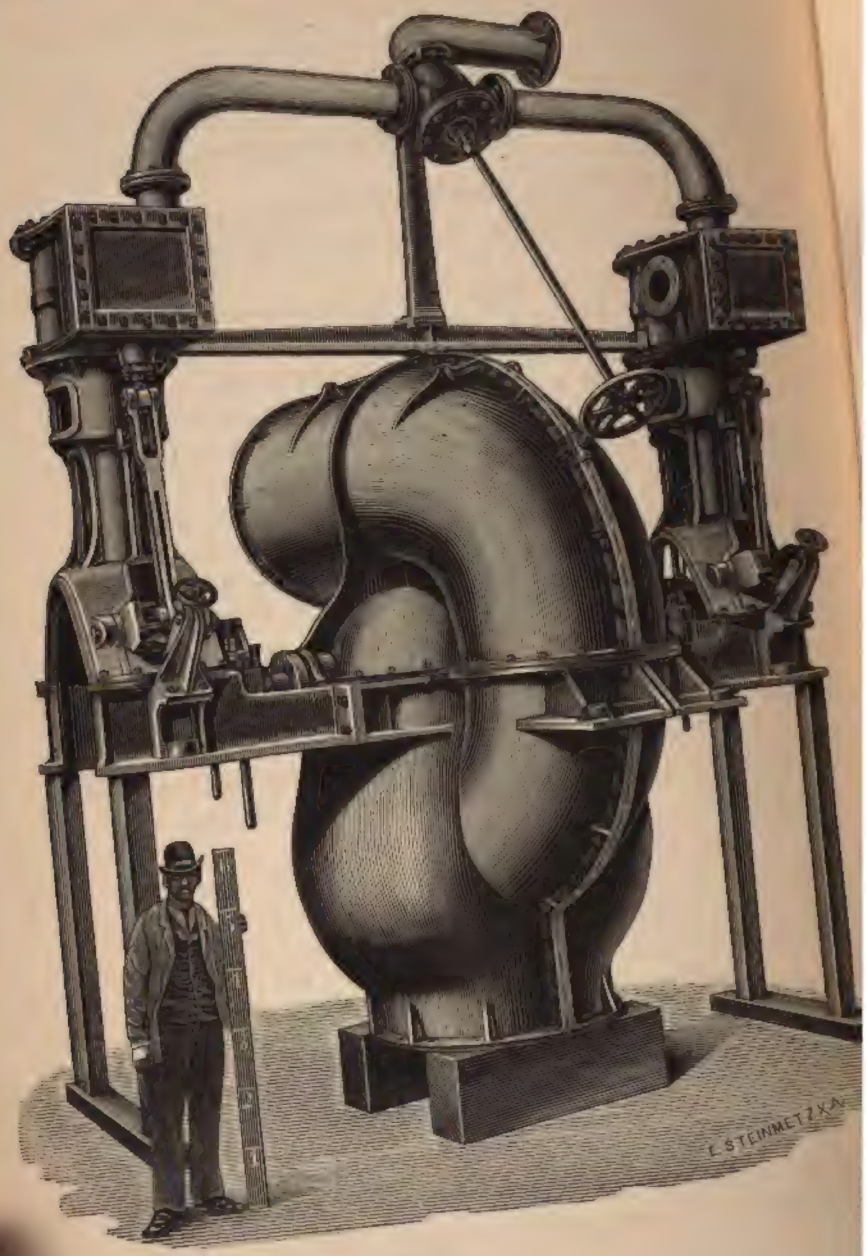
Contributions to the literature of Waterworks generally have been received from a few provincial and foreign water companies. The Chester Waterworks Company also exhibit an old wooden pipe formerly used for conveying water to that city.

The principal entrance to the Pavilion on the east side is in the form of a Gothic arch, constructed of main pipes, joints, and bends used by the Companies for the supply of water.

In the garden adjoining the Water Pavilion is a separate building containing specimens of various laboratory apparatus used in making analyses of water, and in the centre of this garden is another fountain with mermaids.

Between this fountain and the Gothic arch above-mentioned is a wrought-iron standard, thirty-six feet in height, constructed by Mr. Newman for the Duke of Westminster. This standard carries the electric light for the illumination of the garden, which has been supplied by the Electric Sun Lamp and Power Company. The crystal gas illuminations in this garden have been lent by Messrs. Defries & Sons, who have likewise constructed the glass illuminated cascades in the four canals.

In the garden adjoining the Pavilion Messrs. Simpson & Co., Engineers, of Pimlico, exhibit a large centrifugal pump and engines combined, suitable for irrigation or


E. STEINMETZ X.A.

drainage, being the largest pump of the kind which has yet been constructed. (See *Drawing*, p. 686.)

The pump is one of four made for the Graving Docks of the new East and West India Docks at Tilbury, and will discharge 10,000 tons, or 2,240,000 gallons, of water per hour.

The maximum quantity of water that the water companies have power to abstract from the Thames is 110,000,000 gallons per day, or about 4,600,000 gallons per hour, so that two pumps of the size exhibited would be capable of lifting as much water as the Companies can take from the Thames. Ten thousand tons of water an hour are equal to a stream of water 50 feet wide and 1 foot deep, flowing at a velocity of 2 feet per second, and will cover 100 acres to a depth of 1 inch.

The pump is driven by two engines, one at each end of the crank-shaft, the cylinders being 22 inches diameter and 16½ inch stroke. They are fitted with "Joy's valve gear," so as to enable the steam to be used in the most economical manner.

The suction and delivery pipes of the pump are not exhibited, but the sizes may be of interest; they are: suction-pipe, 4 feet in diameter at the pump, enlarging to 7 feet diameter in a length of 9 feet; and delivery-pipe, 44 inches at the pump, increasing to 60 inches in a length of 12 feet.

DESCRIPTION OF THE ILLUMINATED FOUNTAINS.

In the ornamental water in the grounds of the Exhibition fountains of various designs have been arranged, which are illuminated after dark by means of the electric light. The electrical and optical arrangements connected with the illuminations of the fountains have been carried out by Sir Francis Bolton; the jets and fountain arrangements having been executed to his designs by Messrs. Baskervill & Pittman. The telegraphic signalling apparatus has been supplied by Messrs. J. & W. E. Archbutt.

The water supply for the fountains is furnished by the West Middlesex Waterworks Company, under their engineer, Mr. Thomas Hack, C.E.; the pipes for the fountains were constructed from Sir Francis Bolton's designs by Messrs. Simpson & Co., and the water mains laid by Messrs. Lucas & Aird, under the supervision of Mr. Bell, of the West Middlesex Water Company.

The special divers' dresses have been furnished by Messrs. Siebe & Gorman. The Rev. C. Berthon has kindly lent the collapsible boat used in the ornamental water in the grounds.

The following is a description of the means by which the effects shown by the fountains are produced:—

The water for supplying the fountains is delivered direct from the West Middlesex Water Company's Hammersmith reservoir. The main enters the Exhibition grounds from the north-west, and is conducted to the four water-meters, on the western side of the centre basin, which register the quantity of water consumed. From this point a large main leads to the "island" in the centre of the basin, where the principal jets rise. The water is supplied with a pressure of about seventy pounds to the square inch, which is sufficient to carry it to a height of 120 feet.

The wires for supplying the electric light are thoroughly insulated, and are conveyed to the island enclosed in lead pipes to protect the insulation.

The whole of the jets are worked by screw-valves and levers placed inside the island.

The fountain display is directed from the clock tower at the south side of the garden, the "operating-room" being behind the dial of the large clock. The operator controls not only the working of the jets, but also the colour and power of the lights, by a series of electric signals. In front of him is a board with twenty "pushes," which communicate with bells and indicators inside the island. The bell-pushes are labelled "call," "on," "off," and "steady," while the indicator-pushes are marked with the names of different colours and valves.

The illumination of the water-spray, which produces brilliant effects when falling, is effected from the clock-tower.

In the "operating-room" are two "Brush" arcs, of 2000-candle power each. These are assisted by the holophote, containing an arc of 10,000-candle power, which is situated in the room above. It is the holophote that reflects the red, white, and blue colours on the cascade, also the parti-colours on the fountains themselves. The colours are sent through a medium of sheet-gelatine stuck on a glass frame similar to a small window. Several of these frames are fitted on a sliding rack, and are raised into position by pulling a string. On the signal being given, the window in position before the holophote is allowed to drop, and another immediately raised, producing a rapid change of colour. These changes are directed by eight electric indicators and a bell.

Higher still is the outside platform, from which the Hockhausen "mast light" is raised and lowered, and, while the fountains are being illuminated, the scarlet shade, in shape like an inverted umbrella, is drawn up to dim this powerful light.

The attention of the engineer in charge inside the island

having first been "called," the "on" bell and the "centre" valve are then touched, and he immediately starts the centre jet, the big fountain. Should a colour bell be rung, a ray of light is seen to illumine the water as it rises from the island. Each signal given from the tower is acknowledged from the island by a reply bell, and notice of intended changes is given to the workers of the holophote above.

The machine-room inside the island is an apartment 21 feet square. Its roof being little over 5 feet from the floor, renders it impossible for the operators to stand upright in it. The floor is crossed and recrossed in all directions by iron pipes, conveying the water from the main to the various jets.

The fountains are set in action by screw-valves fixed vertically on the different branches attached to the water mains. The large jets, which send the water to the greatest heights, are worked by plug-valves and levers, so as to allow an instantaneous start and stop, which causes a shower of spray. There are, altogether, eleven wheels and three levers. The wheels are nearly equidistant round the room, the levers being in the centre.

In the roof are five circular skylights of very strong glass, one of them being exactly in the centre, the others forming a square about it. Under each of these skylights is a wooden stand, on which is fixed a hand arc lamp of 8000-candle power. Over each arc is a lens, which concentrates the light on the jet. When the order "Lights on" is received, the five arcs are set going, the result being to powerfully illumine the jets of water, and produce a glistening effect. The power for the hand-lamps is supplied by a 70-horse power Siemens machine. When the apparatus is about to be set in action, the ventilators, as the narrow side windows are termed, are closed down otherwise the room would be flooded. The usual staff is five—one man to work the valves, three to attend to the lights, and one to watch and reply to the bells. They cannot see what is going on outside, their only means of

knowing that all is right being the signals from the clock tower. The quantity of water sent up averages 70,000 gallons an hour, but while all the jets are going at once 1,000 gallons are used in fifteen seconds. The designs to be thrown on the cascade are worked from a lantern placed inside the island facing the treble fall. The water towers at either side of the statue are capable of throwing a stream of water, containing a ray of electric light, into the basin below with a very beautiful effect.

REFERENCES TO PLANS AND LISTS OF EXHIBITS.

I.—KENT WATERWORKS.

Engineer—Mr. W. MORRIS, M. Inst. C.E.

PLANS.

No. 1, in the centre of the sheet, shows the Deptford works. The river Ravensbourne, from which the company formerly took their supply, flows from east to west; on the south side of the stream is an old disused reservoir; at the west end of the reservoir is the old engine-house, built in 1812, which contains a pair of Boulton and Watt's engines now used for the supply of Blackheath; at the opposite end of the reservoir is the garden engine-house, which contains a 60-inch Cornish engine, raising 2,500 gallons per minute from well No. 1.

On the north side of the stream, at the eastern corner of the plan, is the Cold-bath engine-house, which contains a 60-inch Cornish engine, raising 2,000 gallons per minute from well No. 3. Below this, coloured green, is a meadow; the site was formerly occupied by a subsiding reservoir; adjoining this is the twins engine-house, containing two Cornish engines, one raising 2,500 gallons per minute for well No. 2, the other forcing the water raised from the well into the mains supplying New Cross. The part tinted pale yellow indicates the position of two old filter-beds which have been converted into covered reservoirs; there is a third filter-bed not now in use tinted brown. The remaining engine-house contains a pair of 70-inch Cornish engines, which force the water raised from the wells into the mains supplying Deptford and Greenwich. The land to the west is let to a market gardener. The other buildings consist of the company's offices, dwelling-houses, stores, and workshops. Average daily supply from Deptford, 1883, was 4,172,243 gallons.

No. 2 shows the Plumstead works, which consist of engine-house containing a pumping engine and well; there are also three reservoirs, one of which is covered. Average daily supply, 1883, 412,533 gallons.

No. 3 shows the Crayford works; there are three wells and

three pumping engines at these works, two of which are working continuously, the third being kept in reserve. Average daily supply, 1883, 2,797,587 gallons.

No. 4 shows the company's works at Shortlands, near Bromley; there are two wells and two pumping engines which are constantly at work for the supply of this part of the district. Average daily supply, 1883, 1,476,400 gallons.

No 5 shows the Dover Road Pumping Station; there is no well at these works; the engine-house contains a pair of horizontal engines, used for pumping the water from Woolwich common reservoir for supply of Shooter's Hill.

No. 6 shows the company's works near Orpington, in the parish of Farnborough. The engine-house is built to contain a pair of Cornish engines, of which one only is erected; it is employed in pumping water from a well for the supply of this part of the company's district. Average daily supply for 1883, 714,730 gallons.

EXHIBITS.

1. Morris' patent elastic band valve.
2. Harvey and West's, double beat valve.
3. 1 inch Kennedy's meter.
4. ½ inch Kennedy's meter in action.
5. 3 inch Manchester meter.
6. 6 inch Siemens' meter.
7. ½ inch Siemens' meter, in section, fitted to a bye-pass pipe.
8. 1 inch Siemens' meter.
9. 3 inch Berlin combined meter.
10. 1 inch Berlin meter
11. 1 inch Union meter.
12. ½ inch Parkinson's low-pressure meter.
13. Drum of Parkinson's low pressure meter in action.
14. Morris's patent tapping apparatus, for making connections with mains under pressure, fixed to 18-inch pipe.
15. Morris's patent tapping apparatus, in section, for making connections with mains under pressure, fixed to 10-inch pipe.
16. ½ inch patent ferrule, in section, for use with Morris's tapping apparatus.
17. ¾ inch Morris's patent ferrule.
18. 1 inch Morris's patent ferrule.
19. ½ in., ¾ in., and 1 in. Morris's patent ferrule, with lead pipes attached and fitted to 6-in. pipe.
20. *½ inch driving* ferrule with lead pipe attached.

21. Coburg fitted with ½ inch screw ferrule, used where driving ferrules are removed and replaced by screw ferrules for constant service.

22. ½ inch screw ferrule attached to bye-pass pipe.

23. ½ inch screw ferrule attached to lead pipe with stop-cock.

24. ¾ inch screw ferrule attached to lead pipe.

25. 1 inch screw ferrule attached to lead pipe.

26. ½ inch stop-cock ferrule attached to lead pipe.

Note.—The foregoing seven items are fixed to two pieces of 4-inch pipe.

27. ¾ inch stop-cock ferrule.

28. Tools used by the Company's turncocks and service layers; consisting of turncock's bar key and spoon, pickaxe, shovel, rammer, tool-bag, hammer, two flat chisels, three half-round chisels, brace, rymer, ½ in., ¾ in., and 1 in. taper gas-taps, two spanners, two yarning irons, three caulking irons, screw, wrench, and stop-cock key—making in all 29 articles.

29. 3 inch plug pipe and wood fire-plug.

30. 4 inch plug pipe with frost stand-post.

31. Plug box.

32. 4 inch elbow ball hydrant with fire stand-pipe.

33. 3 inch elbow ball hydrant with lengthening piece for use where the level of the roadway has been raised subsequent to the laying of the pipe.

34. Mode of attaching ball hydrant to ordinary fire-plug pipe in districts placed under constant supply.

35. Hydrant box.

36. 4 inch screw-down fire-cock.

37. 3 inch screw-down fire-cock with frost stand-pipe with section of surface box and brick pit.

38. Stone's "Metropolitan" fire hydrant, as adopted by the Metropolitan Board of Works.

39. Stone's Metropolitan sluice valve in section.

Note.—This sluice valve is placed between two pieces of 4 inch pipe to which are attached various ferrules.

40. Stop-cock box.

41. Crossley's self-registering rain-water gauge.

42. Crossley's self-registering rain-water gauge in action in the grounds.

43. Kennedy's self-closing draw-tap for courts, with cover taken off.

44. Wooden branch pipe with two wooden pipes attached—unearthed in the Greenwich Road on the 9th June, 1884.

45. Glass show case containing :—

Lead pipes twisted by plumbers in screwing up iron pipe.

Defective plumbers' joints.

Laminated lead pipes.

Lead pipes eaten by rats.

Wrought-iron pipes choked with rust.

Wrought-iron pipes corroded by clay soil.

Root of tree found about 14 ft. under ground in excavating for reservoir at Farnborough.

Horn found in excavating at Deptford.

Flints from well at Deptford.

Diagrams and Photographs.

Diagram of Farnborough reservoir.

Diagram of water supply.

14 photographs of Company's works.

16 photographs of reservoirs in course of construction, in four frames.

II.—THE NEW RIVER.

Engineer—Mr. J. Francis, M. Inst. C.E.

Consulting Engineer—Mr. John Taylor, M. Inst. C.E.

Plans.

No. 1.—Chadwell Spring.—A natural spring arising from the chalk at a distance of about one mile north of Ware. Before the year 1613, when the construction of the New River was completed by Sir Hugh Myddelton, this spring discharged itself into the River Lee, but since the above-mentioned date it has been one of the feeders of the New River.

No. 2.—Broad Mead.—A deep chalk well with pumping engine of 16 horse-power.

No. 3.—Amwell End.—A deep chalk well with pumping engine of 50 horse-power.

No. 4.—Amwell Hill.—A deep chalk well with pumping engines of 75 horse-power.

No. 5.—Amwell Marsh.—A deep chalk well with pumping engines of 70 horse-power.

No. 6.—Rye Common.—A deep chalk well with pumping engines of 200 horse-power.

No. 7.—HODDESDON.—A deep chalk well with pumping engine of 50 horse-power.

No. 8.—TURNFORD.—A deep chalk well with pumping engines of 150 horse-power.

No. 9.—CHESHUNT.—A deep chalk well with pumping engine of 20 horse-power; and two storage reservoirs having a total area of 18½ acres and a total available capacity of 39 million gallons.

No. 10.—ENFIELD.—A deep chalk well with pumping engines of 170 horse-power.

No. 11.—BETSTILE, SOUTHGATE.—A deep chalk well with pumping engines of 24 horse-power.

No. 12.—HIGHFIELD, EDMONTON.—A deep chalk well with pumping engines of 210 horse-power.

No. 13.—HORNSEY.—Subsiding reservoirs having a joint area of 8 acres and a total available capacity of 8,500,000 gallons, with eight filter-beds having a joint area of 5¼ acres, and pumping engines of 440 horse-power.

No. 14.—GREEN LANES, STOKE NEWINGTON.—Two subsiding reservoirs having a joint area of 42½ acres and a total available capacity of 90 million gallons; nine filter-beds having a joint area of 9 acres; pumping engines of 1,080 horse-power.

No. 15.—HIGHGATE ARCHWAY.—A covered service reservoir having a capacity of three million gallons, with pumping engines of 75 horse-power.

No. 16.—NEW RIVER HEAD, CLERKENWELL.—Subsiding reservoir having an area of three-quarters of an acre; three filter-beds having a joint area of 2¼ acres: pumping engines of 200 horse-power.

EXHIBITS.

Model of the Metropolitan part of the New River Company's district.

Map of the New River Company's district.

Perspective views of the New River Company's Works.

Pictures, drawings, &c., Portrait of Sir Hugh Myddelton—an Engraving A.D. 1632.

Sir Hugh Myddelton's glory—an engraving.

Sir Hugh Myddelton's autograph—1615.

Receipt for water rent—Pepys the Diarist—1701.

New River Head and North London—old engraving.

New River Head—water colour. A.D. 1730.

Old London Bridge—showing water-wheels.
Old London Bridge Waterworks Machinery—A.D. 1582.
New River Head—Plan showing leaden mains therefrom.
New Balance Engine.
Section of Ware bore hole.
Rye Common, Engines and Well.

Apparatus.

Rye Common, Engines.
Hornsey Lane Reservoir (during construction).
Diamond Drill Apparatus.

Antiquities.

Old wooden pipe.
Pail made out of old wooden pipe from Southampton Row.
Old fashioned flat valve used with wooden pipe.
Section of old leaden pipe.
Old iron pipe—after being 60 years in ground.

Photographs.

Sections of 12″, 6″, 4″, and pipes with lead joints.
16″ main and sluice valve with 6″ branch and pressure reducing valve.
Sluice valves.
Hydrant—as used in the City of London.
Waterphone.
Turncock's tools.
Tylor's patent waste meter.
Water fittings—bearing New River Company's stamp.

Cores from Wells, and Boring Tools.

Specimens from the chalk, upper green-sand, gault, Devonian and Silurian formations.

22½″	diameter diamond	boring crown.
17½″	"	core extractor.
10″	"	auger.
14″	"	shell.
17½″	"	chisel.
24″	"	undercutting chisel.

III.—EAST LONDON WATERWORKS.

Engineer—Mr. W. B. BRYAN, M. Inst. C.E.

PLANS.

No. 1. WALTHAMSTOW.—Eight impounding and storage reservoirs, 220 acres in extent, and of 600,000,000 gallons capacity. Foreman and workmen's houses, deep chalk well and pumps, and turbine of 70 horse-power.

No. 2. BUCKHURST HILL.—High service reservoir; level of water line 327·18 feet above Ordnance datum. Capacity 70,000 gallons.

No. 3. LEE BRIDGE.—The principal pumping and filtering station; area of filters 24¾ acres. Seven pumping engines of 1,050 horse-power. Water wheels, offices, coal stores, workshops, general stores, foreman's house, workmen's cottages, and pipe yard.

No. 4. WOODFORD.—Covered filtered water reservoirs of 3,000,000 gallons capacity. Two pumping engines of 120 horse-power, foreman's house and workman's cottage, offices and stores.

No. 5. OLD FORD.—Pumping station, six pumping engines of 800 horse-power. Covered filtered water reservoir of 3,000,000 gallons capacity, Engineer's residence, grounds, &c. Foreman's house, coal stores, workshops. Survey, district superintendent's and general offices. General stores, landing wharf from Lee, testing houses, pipe yard and stores.

No. 6. THAMES AUXILIARY SUPPLY, SUNBURY.—Intake from Thames. Two pumping engines of 150 horse-power, service tower, foreman's house, coal railway, and landing wharf from Thames.

No. 7. THAMES AUXILIARY SUPPLY, HANWORTH.—Three pumping engines of 600 horse-power. One open reservoir for unfiltered water of 5,000,000 gallons capacity. Two covered filtered water reservoirs of 2,500,000 gallons capacity. Filter-beds of an area of 5 acres. Superintendent's house, offices, stores, coal stores, meter repairing shops, workshops, and pipe yard.

EXHIBITS.

Old double butterfly valve made for the "Twin" engines, 1807.

Set of old cutters for boring wooden pipes. Cutters about 100 years old.

Old pump bucket from Twin Engines, 1807.

Old air-pump bucket from first Cornish engine erected in London.

Old-fashioned gate valve, about 100 years old, found in March, 1884, in the Mile End Road, attached to a piece of wooden pipe.

Old-fashioned gate valve.

Old-fashioned hydrant.

Hydrant used throughout East London Waterworks Company's district in lieu of wooden plugs.

Pipe and wooden plug.

Three water engines, about 40 years old, intended for positive meters.

Valve made of india-rubber pipe inside iron body.

Indicator to measure variable stroke of Cornish engines, as used by the East London Waterworks Company.

Water engine made by Glenfield Company, used by the East London Waterworks Company to work scrapers of Green economizers and also boiler feed pumps.

Recorder used by the East London Waterworks Company for ascertaining duty done by engines.

Two waste preventers, as used in back courts and alleys in East London.

One 3 Lamberts diaphragm valve.

Double beat valve for East London Waterworks Company's engine " Cornish," being the first engine for waterworks purposes erected in London on the Cornish principle.

" Beehive" valve for " Ajax " Engine, at Old Ford.

METERS.

2" Walker's " Duplex " meter.

4" Tylor.

1" Eureka.

$1\frac{1}{2}$" Stirling's low pressure.

$\frac{1}{2}$" Stirling's low pressure.

3" Manchester positive meter.

$\frac{3}{8}$" Manchester positive meter.

3" Kennedy positive meter.

$\frac{3}{8}$" Kennedy positive meter.

$\frac{1}{2}$", $\frac{3}{4}$", 1" and 2" Berlin meters by Siemens and Halske.

$\frac{1}{2}$" American meter " Crown."

$\frac{1}{2}$", $\frac{3}{4}$", 1", 2", 3", 4", 6", 12" Siemens meters.

$\frac{1}{2}$" positive double-cylinder meter, about 40 years old, maker unknown.

Parkinson's low pressure meter.

1" Worthington double-cylinder, positive meter, maker unknown.

$\frac{1}{2}$" Pocock meter.

IV.—SOUTHWARK AND VAUXHALL WATER-WORKS.

Engineer—Mr. J. W. RESTLER, C.E.

PLANS.

No. 1 represents the INTAKES AT HAMPTON, where the river water passes through cast-iron screens into the reservoirs and filter-beds. At the works situated to the north of the Lower Sunbury Road, the river water is pumped by three direct-acting engines, having a nominal horse-power of 450, through a 36-inch main to the Battersea Works.

No. 2. THE WORKS situated to the south of the Lower Sunbury Road consist of reservoir and filter-beds capable of filtering 9,000,000 gallons per day. The engine power consists of two Cornish beam engines of 420 nominal horse-power, delivering the supply through a 30-inch main to the Company's western district, and also to the Company's service reservoirs at Nunhead.

No. 3. BATTERSEA WORKS.—At this station the water is received from the Hampton Works No. 1 into reservoirs capable of containing 46,000,000 gallons, it is then passed through the filter-beds, having an area of 11¼ acres, and is pumped into the district by six engines, having a total of 1,200 nominal horse-power.

No. 4. NUNHEAD WORKS.—At this station part of the water pumped from the Hampton Works No. 2 is received into covered service reservoirs, having a capacity of 12,000,000 gallons, at an elevation of 150 feet above Ordnance datum. Two engines of 100 nominal horse-power raise a portion of this water to two other reservoirs capable of containing 6,000,000 gallons, and situated at an elevation of 200 feet above Ordnance datum, for the purpose of supplying the higher portions of the district.

EXHIBITS.

1. Model of house service connection with Bell's patent stop-cock.
   - *a.* Showing section of cock as fixed in place with guard box and false spindle.
   - *b.* Section of cock with cover removed, and water shut back by bottom valve.
   - *c.* Showing self-feeding, drilling, and tapping apparatus for the insertion of ferrule in mains.
2. Bell and Wheatley's patent flushing cistern as used in the Company's district.

3. Hydrant and standpipe as used in constant supply districts.

4. Models of safety balance valves as fixed at the Company's Hampton and Battersea Works.

5. Model of Husband's patent four-beat pump valves.

6. Specimens of strata passed through in sinking the Company's well at Streatham.

7. Old wooden pipes and stop valves taken out in Redcross Street, Southwark, May, 1884; supposed to have been fixed about 70 years ago.

8. Section of standard 4" double-faced sluice-cock as at present used by the Company.

9. 4" stop valve taken out from Orange Street, Southwark, 1880, supposed to have been fixed 60 years ago.

10. A $\frac{3}{4}$" Paine's water meter.

11. Model of patent steam packed piston as used in the Company's engines.

12. Section of $\frac{1}{2}$" Siemens' water meter.

13. Model of ball and socket joint as used on the Company's 30" main crossing under the Thames at Richmond.

14. Model of Baker's rotary pump, now being erected for the Company, to lift 16,000,000 gallons 16 feet high in 20 hours.

15. Section of Baker's rotary pump, now being erected for the Company, to lift 16,000,000 gallons 16 feet high in 20 hours.

16. Model showing fire-plug and box as fixed in the Company's district, with standpipe and hose in position as used for extinguishing fires.

17. 60" delivery valve for 112" cylinder, 10 feet stroke, with pump plunger, 50 inches diameter, 10 feet stroke, delivering 820 gallons per stroke.

18. 15" double-faced sluice-cock with gun metal spindle of the Company's standard pattern.

19. 12" double-faced sluice-cock with gun metal spindle of the Company's standard pattern.

20. 9" double-faced sluice-cock with gun metal spindle of the Company's standard pattern.

21. 8" double-faced sluice-cock with gun metal spindle of the Company's standard pattern.

22. 7" double-faced sluice-cock with gun metal spindle of the Company's standard pattern.

23. 6" double-faced sluice-cock with gun metal spindle of the Company's standard pattern.

24. 5" double-faced sluice-cock with gun metal spindle of the Company's standard pattern.

25. 4" double-faced sluice-cock with gun metal spindle of the Company's standard pattern.

26. 3" double-faced sluice-cock with gun metal spindle of the Company's standard pattern.

27. 2" double-faced sluice-cock with gun metal spindle of the Company's standard pattern.

28. Husband's patent four-beat pump-valve for 68-inch pump plunger, 10 feet stroke, delivering 340 gallons per stroke.

29. Model of single-acting Cornish beam engine, showing the type of engine in general use by the Company, manufactured by Messrs. Harvey & Co., Hayle, Cornwall.

30. Model of Lancashire boiler 7' 0" diameter, 33' 0" long, with Fox and Hopkinson's patent corrugated flue, as recently made for the Company.

31. Model of Galley's patent rocking fire-bars now being tried by the Company.

32.	Isometrical view of the	Company's	Battersea	Works
33.	"	"	Hampton	"
34.	"	"	Nunhead	"
35.	Elevation of	"	Battersea	"
36.	"	"	Hampton	"
37.	"	"	Nunhead	"

38. Section showing the 30" flexible pipe laid under the Thames at Richmond.

39. General view of the Company's "collecting system" for underground water at Hampton.

40. Section of filter-bed as used by the Company.

V.—WEST MIDDLESEX WATERWORKS.

Engineer—MR. THOMAS HACK, M. INST. C.E.

PLANS.

No. 1 represents the INTAKE AT HAMPTON, where the river water passes through fine wire screens, and is pumped by three direct-acting engines, having a total horse-power of 360, through two 36-inch mains to the

No. 2, SUBSIDING RESERVOIRS AT BARNES. Here the water is allowed to subside, and is afterwards passed through sand filters. (A full-sized model showing the construction of these filters may

be seen to the right of this plan.) There are four subsiding reservoirs having a total area of 37 acres, and eight filter-beds having a total area of 12 acres, at this station. After filtration the water passes through two 36-inch conduits under the bed of the River Thames to the

No. 3, HAMMERSMITH PUMPING STATION, where there are 6 Cornish engines and 2 compound rotative beam engines, having an aggregate horse-power of 1,335. These engines pump through mains which distribute the water into the district.

No. 4, KENSINGTON RESERVOIR, is a storage reservoir for filtered water on Campden Hill, supplied by the Hammersmith engines, and stands at a height of 124 feet above Ordnance datum.

No. 5, BARROW HILL, is another storage reservoir for filtered water, adjoining Primrose Hill Park, supplied from Hammersmith, at a height of 190 feet above Ordnance datum. The water from this reservoir is further raised by two engines of 90 horse-power to the

No. 6, KIDDERPORE RESERVOIR, in the Finchley Road, 323 feet above Ordnance datum, from which the highest parts of the district are supplied.

EXHIBITS.

Water Pavilion.

Painting in oil of the Works at Hampton.

Painting in oil of the Works at Hammersmith.

Map of district (6" Ordnance sheet) showing the area supplied by the Company, &c.

Photograph of pumping station at Hammersmith.

Photograph of pumping station at Hampton.

Photograph of pumping station at Barrow Hill.

Isometrical drawings (tinted and coloured) of the Company's several works, viz. :—

No. 1. Hampton.
No. 2. Barnes.
No. 3. Hammersmith.
No. 4. Kensington.
No. 5. Barrow Hill.
No. 6. Kidderpore.

Section of filter-bed (full size), and glass tube supplying water,

as delivered by the Company, into a glass basin; also copies of the monthly analysis of the water.

Outer Corridor.

A 33-inch cast-iron socket pipe standing on end.

Specimens of wooden pipes, as used by the Company until 1807 for supplying the water into the district.

Specimens of stone pipes, as used by the Company until 1807 for supplying the water into the district.

A 9-inch reflux valve.

Working model (worked by means of a water-wheel) of one of the Company's 150 H.-P. compound beam engines, erected at the Hammersmith pumping station.

Diagram shewing the consumption of steam per I. H. P. of the above.

Photographs of sand-washing machine, Barnes.

" pumping station, Hammersmith.

" " Hampton.

" " Barrow Hill.

Photographs of storage reservoir and filter works, Barnes.

Water supply fittings, as under.

Section of house fitted up as required under the regulations of the Metropolis Water Act, 1871, by Messrs. John Bolding & Sons, for this and the Grand Junction Company, shewing the most approved method of applying the fittings, and containing—

3 W.-C.'s, with various and approved water-waste preventers;

1 urinal, with various and approved water-waste preventers;

Sink with two draw-off valves, one from the rising main, the other from the cistern;

Bath fitted in conformity to the regulations;

1 case containing approved ball valves, draw-off valves, stop valves, ferrules, and other water supply fittings.

In a pit, showing short length of the Company's service, and the method of connecting the house communication pipe, with the service pipe by the stop ferrule.

Screw cocks for mains and services, 2" 3" 4" 5" and 6".

Section of 4" screw cock.

Section of self-acting air valve.

Screw-down air valve.

Short piece of 4" pipe, shewing method of connecting communication pipe to the Company's service pipe previous to 1845.

Short piece of 4" pipe, shewing method of connecting communication pipe to the Company's service pipe previous to 1871.

Short piece of 4" pipe, shewing method of connecting communication pipe to the Company's service pipe at present time.

4 approved water-waste preventers.

Ball valves.

Fire hydrants.

VI.—GRAND JUNCTION WATERWORKS.

Engineer—Mr. A. FRASER, M. Inst. C.E.

PLANS.

NO. 1, HAMPTON.—This view shows the original intake of the company, through which the water is taken from the Thames into two subsiding reservoirs, and from them is pumped to the Kew Station, 7½ miles distant.

From the same reservoirs the water is supplied to three filters, in which the water is purified, and from which it passes into a covered filtered-water reservoir. The supply to the whole of the Low Level District, extending from Hampton to Notting Hill, is drawn from this reservoir, and is distributed by a pair of rotative engines through an independent line of main pipes.

The large storage reservoir occupies 12 acres of land, and contains 45 million gallons of clear water for use during times of flood in the river.

The new intake at the extreme west end of the ground conveys the water from the river by means of perforated pipes, into the natural beds of gravel and sand in which it is purified, and from which it is pumped up in a clear and brilliant condition, similar to spring water. This is made use of chiefly at times of flood in the Thames.

NO. 2, KEW.—This view shows the principal filtering and pumping station of the company. The water which has been pumped from Hampton is received into two storage reservoirs, from which it passes on to 8 filters. From the filters the water runs, after purification, to the engine wells, and is pumped up lofty standpipes, through lines of 30-inch pipes to the company's district east of Notting Hill.

NO. 3, CAMPDEN HILL.—This is the principal storage station of the company for filtered water. It is kept full by pumping at the Kew Station, and comprises three covered reservoirs, situated 130 feet above Ordnance datum, which contain 18 million gallons

of filtered water, and are in connection with pumping machinery capable of supplying the whole of the company's district.

No. 4, KILBURN.—This is the highest reservoir in the company's district for the storage of filtered water; it is situated at an elevation of 250 feet above Ordnance datum, contains 6 million gallons of water, and is covered over.

No. 5, EALING.—This reservoir contains 3 million gallons of filtered water, and is kept full by pumping at Kew; it is 200 feet above Ordnance datum, and is used principally as a reserve in case of fire in the higher parts of the neighbourhood.

EXHIBITS.

A. MODELS.

1. Model of the Kew filtering and pumping station.

2. Model of one of the most recently constructed filters at the Kew Station.

The section of this filter is shown full size, and of the actual materials.

3. Model of the standpipe tower at the Kew Station.

4. Model of the standpipe and chimney tower at the Campden Hill storage and pumping station.

B. DRAWINGS.

1. Plan of all the company's stations on one sheet as they at present exist, drawn to a scale of one chain to an inch, corresponding with the sheet of perspective views.

2. Plan and section of the covered reservoirs at the Campden Hill storage and pumping station.

3. Plan and section of the concrete covered reservoir at the Hampton filtering and pumping station.

4. Plan and section of a sand-washing apparatus, as in use at the filtering stations at Hampton and Kew.

5. Plan and sections to illustrate the method of filtering the river water at Hampton through the natural beds of gravel and sand.

6. Plan of the original works of the company at Paddington, constructed in 1811 by Mr. John Rennie, C.E., for taking water from the Grand Junction Canal.

7. Plan of the company's works at Chelsea, constructed in 1824, from which the river water was pumped to the reservoirs at Paddington, on the abandonment of the supply from the Grand Junction Canal.

8. Plan of the company's works at Kew Bridge, constructed by Mr. William Anderson, a pupil of Mr. John Rennie, in 1835, with the intake laid in the bed of the river, which continued in use down to the year 1852.

9. Section of one of the 70-inch direct-acting Cornish engines, with boilers, at the Campden Hill pumping station.

C. Framed Photographs, Drawings, and Maps.

1. View of the Hampton filtering and pumping station.

2. 3. 4. Do. do. do.

5. Do. New intake for natural filtration.

6. View of one of the filters at the Hampton Station during the process of cleaning, assisted by a movable steam crane.

7. View of the sand-washing apparatus in use.

8. View of the Kew filtering and pumping station.

9. Do.

10. View of the Campden Hill storage and pumping station.

11. View of the standpipe tower at Kew during construction.

12. View of the same when completed.

13. 90-inch cylinder Cornish pumping engine, at the Kew station.

14. View of the covered reservoir at the Campden Hill Station during construction.

15. View of the same.

16. View of the covered reservoir at Kilburn during construction.

17. View of the Kew pumping station, showing the standpipe constructed by Mr. Thomas Wicksteed, taken down when the present tower was erected.

18. 19. 20. Plan and sections of a pair of pumping engines, erected by Messrs. Boulton & Watt at the pumping station at Chelsea in 1824, afterwards removed to the Kew Station, where they are now at work.

21. Plan of works at Chelsea, as designed by Mr. Telford, C.E., 1822.

22. Plan of addition to Paddington works, proposed by Mr. Telford 827.

23. Sketch plan of Paddington and Chelsea works, with connecting mains, dated 1827.

24. Map of Paddington parish in 1828.

25. Do. 1838.

26. Map of Ealing parish in 1777.

27. Historical map of Ealing, 1822.
28. Map of Shadwell Waterworks in 1794.

D. SPECIMENS AND SAMPLES.

1. Specimen of a wooden water-main, as formerly in use in the London streets, taken up about seven years ago.

2. Specimen of a water-main of pottery with cement joints, recently taken up in Piccadilly.

3. Sample of a plug pipe and wooden fire-plug as in present use.

4. „ street plug box and cock box.

5. „ sluice valves as in present use.

6. Samples of meters as in present use.

7. „ Ince's patent joints for repairing lead pipes.

8. „ asbestos lubricating oil used in the cylinders of the pumping engines.

9. Samples of asbestos packing for engines, as used in the pumping stations.

10. Samples of Vulcanite used as seating for the pump valves of the rotative engines.

VII.—LAMBETH WATERWORKS.

Engineers—MR. JOHN TAYLOR, M. Inst. C.E., and
MR. T. F. PARKES, C.E.

PLANS.

No. 1.—MOLESEY.—The new intake, the store reservoirs for river and spring water of 125 million gallons capacity; the pumping engines of 100 horse-power, and the conduit 4½ miles long from the river to the Ditton works, capable of conveying thereto 20 million gallons of water per 24 hours.

No. 2.—LONG DITTON.—The principal pumping station and old intake; filters of nearly 8 acres in extent; service reservoir of 3 million gallons capacity; twelve pumping engines of 1,550 horse-power; offices, coal stores, and machinery for landing coal; workshops, general stores, workmen's cottages and other buildings, and general pipe yard. Two cast-iron mains of 30-inch diameter, each 10½ miles long, to deliver water into the Brixton reservoirs; and the third such main now being laid.

No. 3.—COOMBE, KINGSTON HILL.—Covered reservoir for filtered water of 1,150,000 gallons capacity, pumping mains and turncock's cottage.

No. 4.—ROCK HILL.—Covered filtered-water reservoir of 615,000 gallons capacity; cast-iron tank of 100,000 gallons capacity, elevated on a structure of brickwork and roofed over; standpipe to give additional pressure up to 415 feet above Ordnance datum for high service. Turncock's cottage.

No. 5.—SELHURST.—Filtered-water covered reservoir of 2½ million gallons capacity, with spare land for a duplicate. Turncock's cottage, &c.

No. 6.—STREATHAM.—Two covered reservoirs for filtered water of 7½ million gallons capacity.

No. 7.—NORWOOD.—Covered filtered-water reservoir of 5 million gallons capacity. Turncock's residence, &c. (A model of this station is exhibited.)

No. 8.—BRIXTON.—Second lift pumping station, 2 covered reservoirs holding 12 million gallons of filtered water, 12 pumping engines of 930 horse-power; the company's principal offices; coal and general stores, stabling, workmen's residences, and pipe yards. Cost about £140,000 exclusive of land.

EXHIBITS.

1. District plan.
2. Isometric drawings of the company's works.
3. Coloured sketches of company's works.
4. Plan showing levels of various works.
5. Drawing of floating pipes for drawing off top water from reservoirs.
6. Drawing of section of filter-bed.
7. Diagram showing mode of circulating water in reservoirs.
8. Cartoon diagrams from waste water-meter.
9. Model of district, 1859.
10. Model of Norwood covered reservoir.
11. Mode of connecting communication pipes with company's mains. (Past and present systems.)
12. Section of filtering material.
13. Deacon's waste water-meter in action.
14. Kennedy's meters in action.
15. Reservoir sluice 30-inches diameter
16. Sluice valves from 3 inches to 30 inches in diameter.
17. Sample of 54-inch diameter pipe, forming portion of conduit from Molesey to Ditton.
18. Road watering posts.
19. Turncock's tools.

20. Specimens of defective pipes and fittings discovered by using Deacon's waste water-meters.

21. Samples of water.

VIII.—CHELSEA WATERWORKS.

Engineer—MR. LYN LEA, C.E.

PLANS.

No. 1.—WALTON AND WEST MOLESEY.—At this station the water is taken from the River Thames. The "intake" is situated at the north-western corner of the four "subsidence reservoirs" shown on the plan. The water has first to pass through an iron grating (guarded by a movable wooden screen, so arranged as to prevent any accumulation of weeds, leaves, &c., from being drawn down the grating), and then through double screens of fine wire, into the covered wells, from which the water is pumped into the "regulating tank" (a lift of about 20 feet) by two engines, each of 50 horse-power.

From the "regulating tank" the water can be admitted into any one of the four "subsidence reservoirs," where it is allowed to settle, previous to its being sent by gravitation through the 36-inch conduit pipe to the filters at the Surbiton pumping station, a distance of about 5 miles.

The plan also shows the engine and boiler houses, chimney shaft, coal store, workmen's cottages, &c.

No. 2.—SURBITON.—The water is received at the Surbiton Station for filtration through the 36-inch conduit described. The filter-beds are shown adjoining the river, and are seven in number, of which four or five are usually in work at one time, the remainder being cleaned by the removal of the top layer of sand, which is removed, washed and replaced. The water, after passing slowly through the filters, is collected in the engine wells, whence it is pumped up to the covered reservoirs on Putney Heath by 6 engines of 900 collective horse-power, contained in two houses shown on the plan, on the opposite side of the road to the filter-beds. The engine and boiler houses adjoining the filters are used for drainage purposes.

The other buildings shown on the plan are the boiler houses (containing 20 boilers), two chimney shafts (112 feet in height), a coal store, with hydraulic lift and tramway for unloading and hauling the coal, repairing shops, offices and workmen's cottages.

The filtered water is pumped to an elevation of about 180 feet above the engine wells, to the covered reservoirs on Putney Heath, a distance of over 5 miles, through three lines of pipes.

No. 3.—PUTNEY HEATH.—The covered service reservoirs for the supply of the district are situated on Putney Heath, at a level of about 180 feet above the Ordnance datum. These reservoirs are three in number, with a united area of about 5 acres. The two large ones have each a storage capacity of 5 million gallons, the small one a capacity of 1 million gallons. The reservoirs occupy only one-half the area of land shown on the plan, 5 acres remaining available for future extension if necessary. A cottage for the reservoir keeper is shown on the plan.

From the reservoirs the water flows by gravitation into the district, through four lines of main pipes, crossing the Thames at Putney by an aqueduct now in course of removal for the erection of a new bridge, over which the company's pipes will be eventually carried—a temporary aqueduct being meanwhile provided.

EXHIBITS.

A bird's-eye view of part of the works.

A general plan of the whole of the works, and the company's district from Walton-on-Thames to Charing Cross.

An elevation of Putney aqueduct; size of drawing 6 feet by 2.

A framed and glazed drawing of the large pumping engines, &c.; size, 4 feet 6 by 2 feet 6.

A ditto of the smaller engines at West Molesey; size, 4 feet by 2 feet.

2 old maps of Chelsea district, 4 feet by 2 feet, date about 1810.

1 old fashioned (butterfly) valve.

1 ancient fire-plug on a 5-inch pipe.

A Portuguese water-meter.

An old iron water-gauge box.

A modern road-watering hose and fire-hydrant, about 7 feet high.

A section of the high-service reservoir.

An enlargement of the print of old works by Briscoe.

Portrait of the late Mr. Simpson.

The Company's arms in cast iron, dated 1723.

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